A COMPREHENSIVE GUIDE TO PLASTICS PROCESSES AND PRODUCTS

Industrial Arts PLASTICS

LAUTON EDWARDS

INDUSTRIAL ARTS PLASTICS

SECOND EDITION

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LAUTON EDWARDS

FOREWORD

Interest in plastics has greatly increased in recent years. This is, no doubt, partly due to the fact that plastic is a relatively new material as compared with wood, metal, or leather, but it is also partly due to the fact that plastic production and fabricating has become one of our nation's large industries.

There is a growing tendency on the part of the leaders in the field of industrial education to include plastics as a major subject. This tendency is supported by an increasing number of articles in magazines promoting wider use of plastics courses in our schools. For example, Mr. Robert R. Shields, writing in an issue of *School Shop*, makes the following statement:

> It is very important that administrators and teachers investigate the possibilities of expanding work offered in plastics because, as the Committee on Plastics Education recently reported, "The plastics industry is still relatively young, rapidly expanding, and changing so quickly that it is hard to predict its future character. We are certain, however, that it will need increasing numbers of trained technicians, engineers, and scientists to keep up with its expansion and to solve the new problems constantly arising."

Care has been taken to identify plastics by their *properties* and *uses* as well as to explain industry's methods of producing items made of plastic.

The *use of shop equipment* in the working of plastic is discussed in considerable detail: sawing, sanding, buffing, carving, coloring, welding, forming, cementing, drilling, threading, and laminating.

The *making of equipment* such as molds, jigs, ovens, and forming presses has been treated. Detailed explanations of *operations* such as carving, etching, engraving, turning, molding, threading, pipe fitting, cementing, and coloring have been given.

Effort has been made to encourage *individual talents and abilities* in suggested experiments using a wide range of plastics and other materials. The making and repair of "fiberglas" projects have been discussed in detail.

We like to work in the plastic shop for various reasons. We like to experience the joy of making something as our own creations; we like to make things as gifts for others; and we like to work with and learn about interesting materials. We want to be prepared

to teach what is known at the present as well as to do our share of experimenting in developing for the future.

Whatever reason or reasons people may have for working in plastics, they develop skill and acquire knowledge that will help them to find a better place for themselves in life.

CONTENTS

GLOSSARY OF PROCESSING TERMS

Accelerator: An active oxidizing material, such as manganese metal, used in conjunction with a catalyst (see below) to produce internal heat in liquid plastic as a cure.

Acetone: An organic-carbonyl fluid used to mix with plastic pigmented powder for making a liquid plastic dye. It may also be used as a cleaning fluid.

Adhesive: A liquid or paste used to bond materials.

Annealing: The process of heating plastic close to its melting point as a conditioning for welding.

Air bubbles: Air pockets in a plastic resin and glass fiber lay-up "sandwich." These bubbles are pressed out of the glass fibers and resin before it cures.

Automatic molding: Accomplished by machines and accessories which will mold an item after being set, without manual aid.

Blisters: Defects on plastic caused by improper heating.

Calendering: Processing thermoplastic into film and sheeting, by passing the plastic between a series of heated revolving rollers. The thickness of the finished material is controlled by the space between the rolls.

Catalyst: A material added to plastic resin to make it cure more rapidly.

Cavity: A portion of a mold. Usually these are small portions of the molds that create concern in forcing material into them when molding.

Crazing: Fine cracks in plastic. Some of the causes are improper heating, glues, thinners, or overheating through buffing.

Cure: To change from a liquid to a solid through chemical reaction. Usually this is accomplished by a catalyst added to a resin which will cause a specific chemical reaction when heated.

Cushion: The portion of plastic softened by soaking in a solvent used for cementing. This cushion is usually made for gluing.

Cycle: The different steps used to mold an item, usually spoken of in connection with compression and injection molding.

Decorative sheet: A plastic material that has been formed in color combination.

Density: Pounds per cubic foot and weight per unit volume of a substance.

Die cutting: Cutting parts to the same shape. A jig consisting of metal parts shaped in such a way as to cut many items the same shape and size.

Drum tumbler: A drum equipped with attachments to enable turning end over end at a controlled speed. The uses are to color plastic pellets and to polish plastic items.

Dry coloring: A method commonly

used for coloring plastic by tumbling, using a drum tumbler and dyes or pigments.

Extrusion: The heating of a plastic material and forcing it through a mold and into a cooling station in a more-or-less continuous fashion.

Fabricate: To work material into a finished item by machining, forming, or other operations.

Feather: Beveling the edge of a hole in fiber glass. This is done to make a strong smooth patch.

"Fiberglas": Trade-name of fibers made from glass, similar to wood or cotton fibers. Provided in different forms, such as mat, chopped strands, roving, and woven.

Filler: A substance added to make a material less costly or to change the physical properties.

Film: A thin sheet, 0.010 in thickness or thinner.

Flow line: A line formed due to heating while welding.

Gel: A jellylike plastic resin, in between the stages of a liquid and a solid, or a partially cured plastic resin.

Gel coat: A thin outer layer of properly cured plastic resin. Sometimes it contains color pigments. It is free of glass fibers.

Grit: Determines the coarseness or fineness of sandpaper, the number of sand grit per square inch. The larger the number, the finer the sandpaper.

High polish: Securing finish that is free of streaks or dull parts.

Hopper: A storing place for material to be fed into an injection molding machine.

Hot stamping: An engraving operation for marking material. Heated metal dies are pressed on to plastic and form the contour of the die. It is used with dyes or pigments to stamp names, emblems, or numbers.

Injection: See *Mold.*

Jig: A tool for holding parts of an assembly during the fabricating process, such as for machining, forming, or gluing.

Lamination: A bonded product composed of layers of material. Usually by means of heat and pressure, lay-ups of fiber glass are heated by chemical reaction. Some are cured under pressure, while others need no pressure, such as boats and tanks made of fiber glass lay-ups.

Lay-up: The process of placing reinforcing material in position on the mold and applying prepared resin.

Mat: A uniformly distributed amount of glass fibers, usually used in fiber glass lay-ups; a portion of the material for making a fiber glass item.

Mold: A tool made to form plastic items. To form a plastic item by compression or injection molding, the plastic is placed or forced into the proper shape. It is also used in such forms as blow molding, whereby the heated sheet plastic is blown to form the item.

Mold release: A mold-coating substance used to prevent the item from sticking to the mold. Sometimes this is spoken of as a *parting agent.*

Molding powder: A plastic material ready for use in the molding operation, usually consisting of plastic granulation, filler, and coloring pigments.

Monomer: A compound which can react to form a polymer; an unpolymerized form of a compound. See *Polymerization.*

Opaque plastic: Material that cannot be seen through and will not permit light to pass through.

Optical clarity: Plastic that is clear, transparent. May be seen through.

Pantograph: A simple duplicating machine guided by a coordinated motion in engraving. Most pantographs are equipped with a variable reducing feature permitting the work to be smaller than the model while retaining the same proportions.

Pellets: Plastic formed in beadlike shapes for heating.

Pill: A compressed tablet of plastic used for accuracy in weighing material; preformed for efficiency in molding.

Pitch: A tar substance, found in some woods. It causes poor laminates of fiber glass. Boat hulls with a tar substance are not suitable for fiber glass covers.

Plastic tooling: Making dies, jigs, and molds from plastic, which are then used as tools to form metal parts such as car fenders. (See Fig. 2-5.)

Platens: The plates of a laminating press, constructed to be heated, cooled, and pressed together. They are the molding plates of the press.

Polymerization: A chemical reaction in which molecules are linked together to cause a cure; the reaction needed to change a liquid to a solid.

Pot life: The period of time during which a resin and catalyst mix is workable.

Preheating: The heating of a compound prior to molding, to reduce the molding cycle.

Premix: Plastic resin, filler, glass fibers mixed together and used as a "do it yourself" kit.

Release agent: A substance used to cover the mold to keep the plastic from sticking.

Resin A plastic material in solid, semi-solid, or liquid forms, which may be used to form items by heating and by the adding of a catalyst.

Roving: A form of glass fibers woven into a rope, usually sixty strands. Roving glass fibers are used to make chopped glass for spray-ups, and also items such as reels for fishing rods.

Sandwich: The stacking of materials to form a laminate, used in layering pictures, paper clippings, stamps, or coins, with the use of a press or the laying up of layers of glass fiber material and plastic resins.

Saturate: Applying plastic resin to glass fibers until the fibers have absorbed all the resin they can hold; used to make fiber glass items.

Shot: The amount of material for one complete molding cycle.

Slug: A small unshaped piece of waste metal.

Solvent: A substance which will dissolve another; usually a liquid which will dissolve a solid.

Sprue: A waste piece which hangs onto the molded product and must be taken off. It is formed in the passageway between the cold mold and the hot mold.

Storage life: The time during which a plastic material can be kept and remain suitable for use. Conditions such as temperature will vary the period with plastic resin. This is sometimes called *shelf life.*

Tack: A spot fastening two items together with glue or heat; usually used to hold two or more parts in place to weld or laminate.

Tacky or sticky: The condition between a liquid and a complete solid; sticky to the touch.

Thermoplastic: A plastic capable of being repeatedly softened by heat and hardened by cooling.

Thermoset: A plastic that will undergo only one cycle of heating and cooling.

Thinner: A liquid that when added to a substance will thin the material, usually shellac and paints.

Translucent plastic: Material that permits light to go through but cannot be seen through clearly; between transparent and opaque.

Transparent plastic: A material that may be seen through clearly.

Tumbling: Finishing a coloring operation by rotating in a barrel together with wooden pegs, sawdust, polishing compounds, or color compounds.

Working time: The time during which a liquid mixture of plastic resin is usable. After this, the plastic will gel, in a stage between a liquid and a solid.

1 PROPERTIES AND USES

This discussion of the properties and uses of plastic is not intended to be thorough enough for the plastic engineer to determine a complicated material for a particular item. It is intended to inform the student of available standard plastics as well as to offer some information concerning their many uses.

A complete list of all trade names would number into the hundreds. It is not intended here to give each of these and their precise qualities, but to discuss them in their broader aspects and to make their properties and uses understandable.

Plastics are sold in the form of granules, powder, pellets, flakes, liquid resins, sheets, rods, tubes, foam, and film.

The plastic processors are divided into six classifications:

1. *Molders.* Produce a finished product by forming the plastic in a mold.

2. *Extruders.* Divided into two groups:

   • Extruders of sheets, film, sheeting, rods, tubing of special shapes, and pipe.

   • Extruders of threadlike plastic which is woven into cloth for seat covers, upholstering, or other fabrics.

3. *Film and sheeting processors.* Producers of calendered, cast, or extruded sheets.

4. *Pressure laminators.* Form sheets, rods, and tubes from resin solutions.

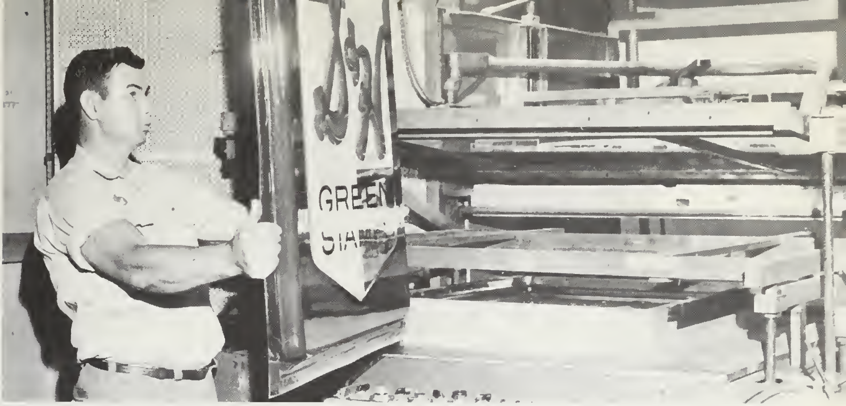
5. *Reinforced plastic.* Manufacturers combine polyesters and Epoxies (see list page 15) to reinforce such materials as glass fibers, asbestos, and plywood.

6. *Coaters.* Do coating, calendering, and dipping to coat fabric and paper with plastic.

Without going into their formulas, thermoset and thermoplastic are the two main kinds of plastics. See Glossary.

Edge lighting.

ROHM AND HAAS



BENCO PLASTIC INC.

Acrylic plastic sign.

Unlike wood, plastic is manmade. The long list of different plastics grows year by year as the chemist continues his search for more and better uses.

Industrial uses now include plastic instead of glass for windows and light fixtures and as a substitute for wood and plaster in walls. Builders use plastic for floors and carpets. Even the imitation grass used on football fields is a plastic material.

Each type of plastic has its own individual properties and is selected by industry on this basis.

Generally speaking, plastics are classified as follows, although they are sold under various trade names:

1. Acrylics.
2. Acetal resin.
3. Acrylonitrile-Butadiene-Styrene (known as ABS).
4. Alkyds.
5. Allyl resins.
6. Casein.
7. Cellulosics.
8. Epoxy.
9. Fluorocarbons.
10. Melamine (amino).
11. Nylon.
12. Phenolics.
13. Phenol-formaldehyde.
14. Polycarbonate.
15. Polyesters.
16. Polyethylene.
17. Polypropylenes.
18. Polystyrene.
19. Silicones.
20. Urethanes.
21. Vinyls.

Main properties and uses are:

1. ACRYLIC PLASTICS. The principal ingredient is methyl methacrylate. It is produced clear, transparent, translucent, opaque, and as a molding powder. Acrylic plastic is a *thermoplastic.*

Clear acrylics have good light transmission (light is transmitted around curves with a crystal-clear acrylic). Because they have good weather and temperature resistance, they make good electrical insulators.

They are used in signs, home appliances, automobile hardware, airplane canopies, TV lenses, costume jewelry, plates, bowls, name plates, counter displays, reflectors, and other accessories.

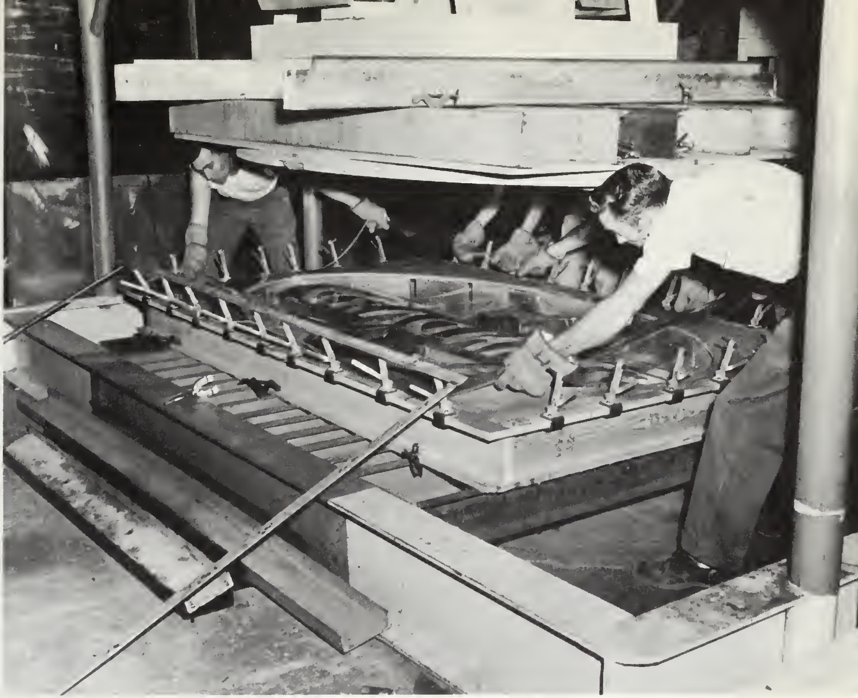
Acrylite and Plexiglas, both acrylic plastics, are good materials for sign production. Acrylite also has a texture useful in the building industry. This plastic is often used for colorful designs on interior walls, room dividers in home and office, windows, and light fixtures.

Acrylics are produced in different formulations, even under the same trade name, to provide specific properties required for various types of application. For example, *Plexiglas G.* sheets are unshrunk. When heated to forming temperature, they will show a shrinkage of approximately 2% in length and width but will increase approximately 4% in thickness. *Plexiglas II UVA* is preshrunk and manufactured to a standard of optical quality, surface quality, and thickness tolerance. *Plexiglas I-A UVA* is useful for solvent dyeing. It has lower heat and craze resistance, therefore should not be used for outdoor signs. *Plexiglas 55* is a cast acrylic sheet superior in resistance to crazing and service temperature. These properties are important to aircraft applications. *Plexiglas 5009* is a flame-resistant, cast acrylic sheet which is recommended for indoor applications.

2. Acetal resin. This is a *thermoplastic* produced in powder form for molding and extrusion. It has high strength and stiffness, with chemical resistance to most

A mold for forming a plastic sign.

PLASTI-LINE, INC.



PLASTI-LINE, INC.

Forming a plastic sign.

solvents. It is replacing metal in die-casting due to its strength and toughness. Other uses are for shoe heels, tooth brush handles, pump parts, carburetor parts, gears, bearings, and plumbing fixtures.

3. ABS PLASTIC. Acrylonitrile butadiene styrene is a *thermoplastic*. It has a chemical resistance to acids and has good over-all electrical properties. It is produced in powder, sheet, and granule form for injection molding, extrusion, calendering, and vacuum-forming. Some of its uses are: to produce refrigerator parts, football helmets, battery cases, automotive parts, utensil handles, and radio cases.

4. ALKYD. This is a *thermosetting* plastic produced in three forms: granular, putty, and glass-reinforced.

The major use of the *granular* type is for vacuum tube bases, automobile ignition systems, and transformer boards. These are items that are used when a relatively high temperature is a factor. The putty type alkyd is used because of its electrical and thermal properties. However, it is af-

fected by temperature changes. The colorful sheets, rods, and tubes are machined to make finished products. Typical uses are for buckles, buttons, and novelties.

5. ALLYL RESINS. These are *thermosetting* resins which cure with peroxide catalysts. and have good insulation resistance. They are used in making switches, connectors, resistors, and decorative laminates. They may be obtained in a wide range of colors, and are available in molding powder and in monomers and prepolymers.

6. CASEIN. This *thermosetting* plastic is used to make beads, buttons, and knife handles, and is widely used as an adhesive. Color possibilites are numerous, and it takes a high polish. It is affected by wide variation of temperature and therefore is not recommended for outside use. It is available in liquid, powder, sheets, rods, and tubes.

7. CELLULOSICS. This is a *thermoplastic* divided into five types, namely, *cellulose nitrate, cellulose acetate, cellulose acetate butyrate, ethyl cellulose*, and *cellulose propionate*. These plastics are among the toughest available. They are provided in a wide variety of colors, as well as transparent, translucent, opaque, and clear.

The cellulosics will stand moderate heat but should not be exposed to continuous outdoor weathering. Some of their uses are: for toys, lamps, shoe heels, spectacle frames, pens and pencils, telephones, appliance housing, and fabric coating. All have good electric resistance.

8. EPOXY RESIN. These are *thermosetting* materials produced as molding compounds, resins, foamed blocks, liquid solutions, and adhesives.

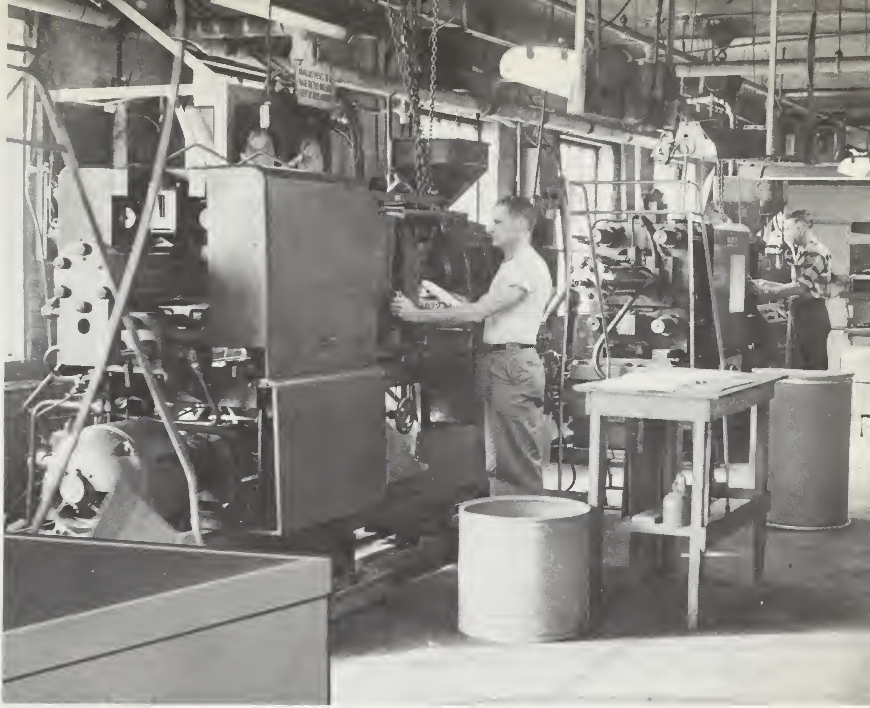
Typical uses are for coating gymnasium floors and household appliances. They are also used with glass fibers to produce reinforced plastic products.

Epoxy resins are used with phenolic and urea resins because the blends are heat convertible and produce hard, durable, and flexible films with resistance to solvents and chemicals. These films are used for lining drums and tanks.

9. FLUOROCARBONS. These are *thermoplastic* materials, available in tubes, sheets, rods, film, powder, and granules. The film, used for packaging, is tough, colorless, clear, and will not absorb moisture. Other uses for fluorocarbon: gaskets, bearing surfaces, conveyor belts, and laminations.

10. MELAMINE. A *thermosetting* material, this is available in molding powder or granules, and as a resin. It can be obtained in a wide range of colors, or colorless. Uses are in production of dinner ware, adhesives, and decorative laminates.

11. NYLON. This is a family name for a group of *thermoplastics*, the polymides. The common nylon compounds can all be handled in conventional machines



PATENT BUTTON CO.

Injection molding machines used to form plastic items from urethane, melamine, phenolics, alkyds, nylon, acrylics, polyethylene, polystyrene, acetate, and vinyl plastics.

with little modification of equipment or procedures. Some materials have a sharp or precise melting point and a low viscosity, thus requiring the molds to be filled quickly.

Nylon has very good electrical and corrosive resistance. It is produced in a molding powder, sheets, rods, tubes, and filaments.

Extrusion-grade materials have a higher melt viscosity. Nylon in stock shapes and sizes can be machined.

Nylon is tough, as it has high tensile, impact, and flexural strength. It is affected by mineral acids. Some foods will stain it, such as coffee and tea.

12. PHENOLICS. This is a *thermosetting*, cold molded material. This plastic is one of the oldest and cheapest, although it has limited uses. Phenolics is resistant to heat and to most corrosive agents. It exists in either solid or liquid form. Very fine powder resins of this type are used for the manufacture of molding compounds, especially in the foundry trade for shell molding.

Liquid resins and varnishes

are used extensively in the laminating industry, as well as for formulation of protective coatings and adhesives. These low cost resins are outstanding in dimensional stability, heat resistance, and resistance to cold flow.

Some other uses of the material are in the production of insulation, brake linings, and abrasive wheels. To use it as a brake lining material, it is mixed with asbestos fibers and pressed after being heated. Before curing, the linings are die cut and then cured under heat and pressure.

13. PHENOL-FORMALDEHYDE. This *thermosetting* material is available as a molding compound, as preform blanks, as bonding agents, as a coating, and as foamed resins. It may be used in laminating, casting, compressing, and plunger molding.

14. POLYCARBONATE. This *thermoplastic* is much less affected by pressure than others are. Viscosity varies sharply with temperature change. It is used for housings of business machines, communication equipment, and electrical apparatus such as coil forms, connectors, and switch parts.

An appliance knob made of phenolic plastic material.

PATENT BUTTON CO.

15. POLYESTER. These are *thermosetting* materials produced as a liquid, powder, or premix molding compound, and as sheets, rods, and tubes. Polyesters can be formed at low pressure and room temperatures, and finished with a superior surface hardening. The most important of their general properties is their ease of handling. Polyesters are produced as light colored liquid which can be colored to the desired shade. They have electrical resistance and long lasting properties.

Polyester resins can be used to reinforce fibrous glass. This resin is used in boat hulls, aircraft glazing, skylights, and translucent roofs. The premix resins are used heavily for fiber cloth or mats, and for synthetic fiber lay-ups.

16. POLYETHYLENE. This is a *thermoplastic* available in powder, sheet, filament, rod, and tube; comes in clear, transparent, translucent, or opaque colors. Polyethylene is one of the most widely used plastics on the market. It is produced in a low-density, a high-density, and a medium-density type.

Uses of polyethylene have grown because of its nonbreakability, flexibility, ease of processing, low cost, and chemical resistance. Some of the many uses

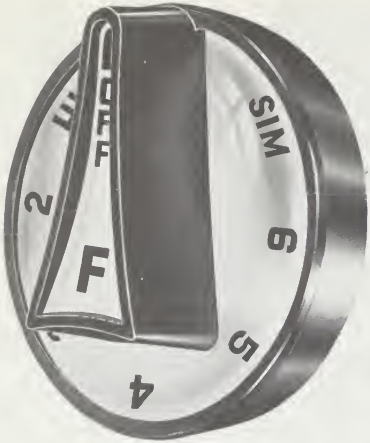
REPUBLIC AVIATION CORP. AND SHELL CHEMICAL

Engineers discuss their Epon, resin-faced drop-hammer die.

are for squeeze bottles, pipes, tubing, bags for foods, rain capes, silo covers, and insulation. This plastic can stand very low temperatures and has very good heat resistance. However, *it should not be used over an open flame or other heating device.*

17. POLYPROPYLENE. A *thermoplastic,* this is resistant to solvents, greases, and oils. It is not recommended for use in strong oxidizing atmospheres. It is used as film for packaging, for wire and cable coating, auto seat covers, dishes, dishwashing machine parts, and housings.

18. POLYSTYRENE. This is a *thermoplastic* material produced in molding powder, granules, sheets, rods, foamed blocks, liquid and adhesives. It comes clear as well as in colors. It is produced in different types, such as unmodified, chemical-resistant, and heat-resistant, to meet industry's individual needs. Normally, styrene does not resist outdoor weathering. However, there is a special styrene developed for this purpose. Some of the many uses are: for kitchen items, food containers, toys, wall tile, radio housings, pipe fittings, wheels, helmets, and extruded pipe. It has good optical qualities, is tasteless, odorless, and has chemical resistance to most household acids.



PATENT BUTTON CO.

An appliance knob made of urethane plastic material.

19. SILICONE. *Thermoplastics.* Are best known as a release agent. Applied to molds and dies, silicones are thus widely used in the plastic, rubber, glass, and metal industries. Other uses are for switch parts, insulation for motors, and generator coils.

20. URETHANES. Are used in making mattresses, sponges, mats, pads, and insulated cloth. These *thermoplastics* can be produced with a varying degree of shock resistance. They have good resistance to chemicals and are good electrical insulators. They are outstanding as an adhesive to synthetic rubber, synthetic fibers, and in uniting rubber to metal. This makes them especially useful to the tire industry.

21. VINYLS. Are *thermoplastics* produced in seven different types, each with individual characteristics: One of the major uses is as pipe for petroleum gas, irrigation and water systems, and electric conduit.

The flexible vinyls are also used for raincoats, garment bags, shower curtains, upholstery, draperies, garden hoses, phonograph records, gaskets, book covers, and wall covering.

All types of vinyls are resistant to water, heat, cold, cleaning fluid, oils, food, and gasoline. They are produced in a wide range of colors as well as clear, translucent, and opaque.

Questions on Types and Uses of Plastics

1. Name six shapes and forms in which plastic may be purchased
2. What are the different classifications of the plastic processors?
3. What is the difference between thermosetting and thermoplastic resins?
4. What are some uses of acrylic plastics?
5. What kind of plastics are acetal resins?
6. What are some of the uses of ABS plastics?
7. In what forms are alkyd plastics produced?
8. What are some of the properties of allylic plastics?
9. What are the two types of amino resin plastics?
10. What are the five types of the plastic cellulosics?
11. What are the major industrial uses of the epoxy resins?

12. In what forms are nylon plastics produced?
13. What are some of the major industrial uses of polyester plastics?
14. What are some of the properties of polystyrene plastics?
15. What are some of the industrial uses of polythylene plastics?
16. What are some of the industrial uses of urethane plastics?
17. How many types are there of vinyl plastics?
18. What are some of the industrial uses of vinyl plastics?
19. Using the descriptions of twenty-one plastics just covered, list all thermosets and thermoplastics in separate columns.

2 PLASTIC PROCESSING

There are three major types of industries working directly with plastic, namely: (1) *The chemical industry.* This industry develops and produces plastic materials. (2) *The equipment industry.* This industry designs and makes the equipment for working with plastics. (3) *The processing industry.* This industry uses the equipment and material to make plastic items.

In 1942, 500,000 pounds of plastic materials were produced in the United States. In 1961, approximately 6½ billion pounds were produced. It is expected that in the 1980's the volume of plastics used for all purposes will exceed the volume of metal. To achieve such gains, the chemical industry has grown very rapidly. At the same time, the equipment and processing industries have increased production accordingly.

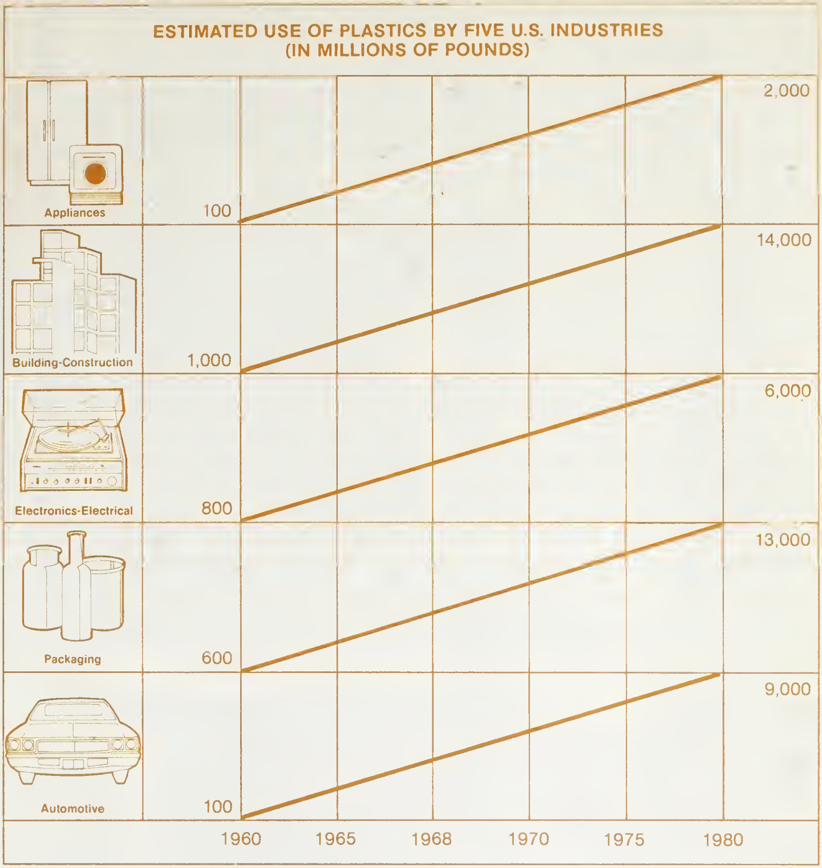
The growth is probably explained by the student of economics as being due to the combined efforts of the three groups to produce items needed and wanted by the customer.

Each individual industrial method varies to some extent in the development of a plastic item. Likewise each school will vary its techniques, usually determined by the equipment available, the types and kinds of plastics chosen to use, and the educational goals.

Typical methods of processing plastic *both* by industry and school are: compression and transfer molding, injection molding, blow molding, dip molding, extrusion, calendering, laminating, and thermoforming. Craftsmen also employ jointing and polishing not described at this point.

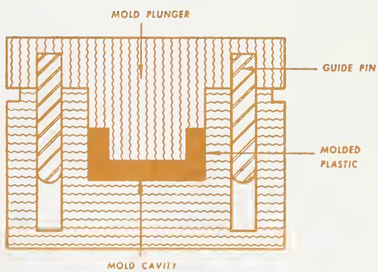
- ***Compression and transfer molding.***

As a rule, *thermosetting* plastics are used for compression molding. Many factors determine the procedure followed, beginning with the size and the thickness of the walls. The shot or the amount of material needed is determined by the size and thickness. The type of plastic used will determine the shrinkage, which will have a bearing on the exact size and shape of the mold, as well as the heating temperature, time for heating, and molding pressure. The amounts and types of fillers used in the resins have much effect on the quality, just as does the type of resins used.



Adapted from a chart in *The Need for Plastics Education*, a national survey conducted by the joint SPE-SPI Education Committee, 1968.

Compression molding is the forcing of material into a mold with pressure and heat. The general procedure is to pre-heat the molding compound in an oven and place in the open mold cavity



Compression molding

THE SOCIETY OF THE PLASTIC INDUSTRY, INC.

or female section of the mold. This pre-heating is not sufficient to mold the plastic. Close the mold and then apply heat and pressure. The heating may be by electricity or by steam. This is done with a downward movement, forcing the male section into all cavities of the mold. The thermosetting materials undergo a chemical reaction, thus hardening into a permanent shape. The mold is then opened and the finished product is taken out.

This mold may be assembled into a fully automatic machine, or it may be connected to a hand operated hydraulic press which is equipped for heating.

There are three compression molding factors: *pressure, temperature,* and *time.* These are determined by the design of the article and the plastic being molded.

The strength of the finished article is determined by the *design, shape* of the mold, *type of plastic* used, and *type of filler* used, if any. The *color* of the article is obtained by coloring the plastic before molding.

A general procedure for compressed molding is as follows:

1. A mold is made that will produce the items wanted. Most plastic processors have their own machine shop and make many of their molds. However, molds also are made by an outside machinist for the plastic processors, and

Compression molding of a radio housing.

PATENT BUTTON CO.

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Placing pre-heated plastic in a compression molding machine.

a processor with a machine shop, may have all complicated molds supplied by a mold maker.

2. The type of plastic to use is determined, by what the items are to be used for, cost of the material, and probable sale of the item.

3. The pills are made from a powder, granular, or pellet form of plastic. Pill size is determined

A patternmaker fashions a master for an aluminum part. The boxed lower half of the pattern (at left) was molded from the mahogany model shown.

INTERNATIONAL HARVESTER CO., AND SHELL CHEMICAL CO.

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An appliance knob made by compression molding.

by the amount of material needed for the item. They are formed by a machine which is set to allow the right amount of plastic material for each pill. Pills must be kept the exact size if the mold is made for no release. If the mold is made for a release, excess material will go out the release, causing a fringe on the item. This fringe may be removed after the item is taken out of the mold.

4. The pills are placed in a preheating oven, which is set for the proper temperature and time. The setting of the temperature control is determined by the kind of plastic used; however, as a rule it is from 300 to 400 degrees F.

5. The pills are taken out of the oven and placed in the mold, which is attached to a machine with hydraulic power. The design of this type machine varies, but the principle is to apply pressure and heat to the mold. Under this

Determining size and shape of a mold to reproduce a plastic item.

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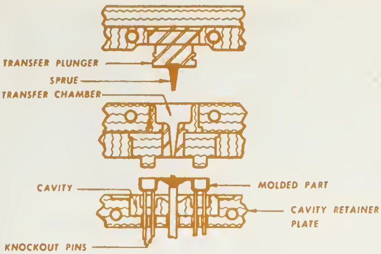
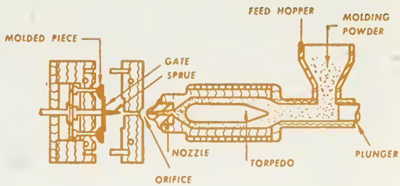


Transfer molding



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Injection molding

pressure and heat the thermosetting plastic goes through a chemical change, at the same time it is being formed into all of the cavities of the mold. It is then taken out of the mold by the pressure being released and the machine's separating at the mold. At the same time, knock-out pins may have been assembled to push the item out of the mold.

Many molds have a parting agent applied before using to assure easy mold release. Silicon spray is a good parting agent. *Transfer molding* is usually used with thermosetting plastic. The method is similar to compression molding. The plastic is heated to a liquid stage and forced into a closed and heated mold. There is a heating unit between the hopper and the mold, and a plunger is used to force in the heated plastic. This method was developed to mold items with small, deep holes. The dry molding compound used in compression molding is not always satisfactory in a mold which requires small pins and metal inserts which form the small holes.

Under the transfer molding method, the plastic is heated to a more liquefied state and is forced into the mold by means of a hydraulically operated plunger. The heated plastic will flow around the pins without causing them to move out of position.

• ***Injection molding.***

Thermoplastic is usually used with this method of molding. In this method the mold remains cold. The heating chamber is between the hopper and the mold. After the plastic is heated, it is forced into the cold mold with a plunger.

The general procedure for injection molding is as follows:

1. The mold is secured as in compression molding.
2. The mold is assembled onto the machine. Unlike compression molding, in injection molding there are no heating elements attached to the mold.
3. The kind of thermoplastic is selected in accordance with the uses of the items to be made. This is usually determined by the plant's plastic engineer.

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Air intake grill made by injection molding.

4. The plastic is prepared for the hopper. It may be that it is to be colored, or two plastics are mixed.

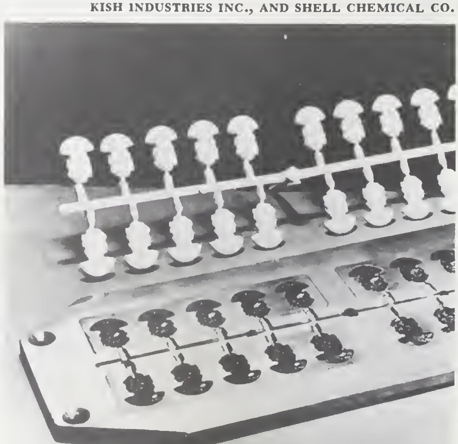
5. The machine is set to heat the plastic properly, to feed it properly, and to force the right amount of heated material into the mold. The size of the mold cavities, plus the sprue, determines the amount of the material —or shot—used for each cycle. This plastic is *formed* as it is forced into the mold; however, it must stay in the mold until it is cool.

6. After the item is cooled, the mold opens up and the item is either released by the mold, pushed out by pins, or taken out by hand. The type of machine determines which method is used.

7. The sprue and other fringe parts are cut off. The plastic cut off is usually cracked and used again. This is possible because it is

Dies fabricated for injection molding. Accurate reproduction molds (as shown here) are obtained quickly and at relatively low cost.

KISH INDUSTRIES INC., AND SHELL CHEMICAL CO.



Valve made of nylon plastic with injection molding.

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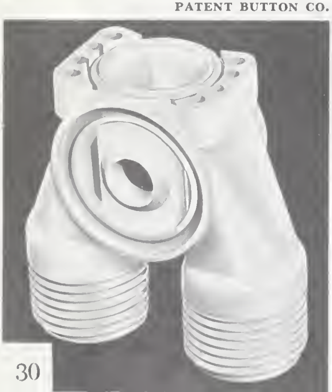


a thermoplastic, which will soften in reheating.

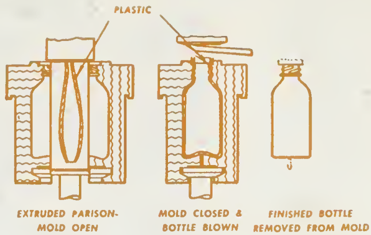
8. Many items require other operations before they are finished, such as adding metal parts, painting, and hot stamping.

- ***Blow molding.***

Thermoplastic material is used for blow molding by two general methods, using sheets and using molding compounds. Blow molding of thermoplastic sheets will be discussed in a later chapter. The blow molding process, with a thermoplastic *compound*, is widely used in making such items as squeeze bottles and buckets.

The procedure for making such items is as follows:

1. Secure a mold that has an inside cavity the shape and size of the item wanted. This mold is to be in two sections, with a means of assembling and separating the sections. A glass bottle *could* be used to form another bottle made of plastic. However, it would have to be broken to get the plastic bottle out!



THE SOCIETY OF THE PLASTIC INDUSTRY, INC.

Blow molding

2. A shot or "gob" of plastic is placed in the mold from the top. Air pressure is used to force the shot around the walls of the mold as into a balloon.

3. This plastic is kept pressed against the walls until the material is cool.

4. The mold sections are then separated and the finished product is removed.

- ***Dip molding.***

Thermoplastic liquid materials are used for this process. The plastic compound may be colored to

Triangular furniture leg and a thermostat cover made of thermosetting plastic.

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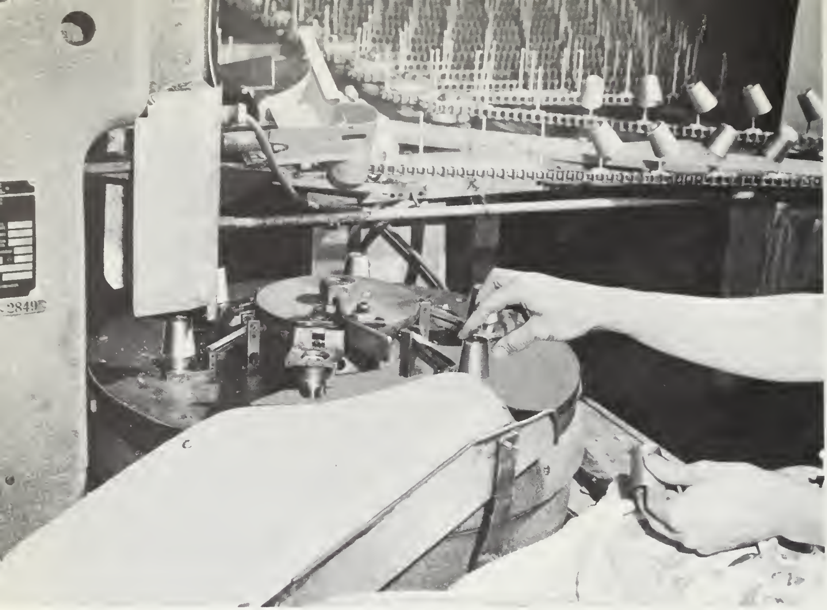

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Furniture legs on an automatic assembly line being drilled, taped, sanded, buffed, and polished.

the desired shade or it may be clear and the finished item painted as desired.

The procedure in dip molding is as follows:

1. Secure a solid mold, usually made of brass, steel, or ceramic.

This may be a mold of a toy car, boots, Halloween masks, or many other open-face items

2. Heat the mold in a preheated oven at 350 degrees F. for a wall thickness of approximately 3/32 inch.

3. Dip the hot mold into the liquid plastic and withdraw it slowly, about 5 inches per minute. This hot mold will fuse the plastic enough to keep about 3/32 inch on the mold.

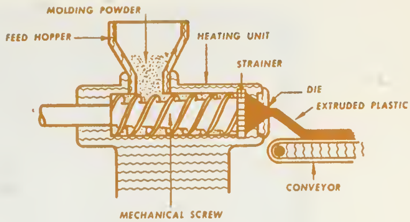
4. Place the mold covered with plastic material in a preheated oven of 350 degrees F. and allow to heat from 5 to 15 minutes. This will fuse the plastic.

5. Remove the mold from the oven and cool by air or water spray.

6. The item is then peeled off of the mold.

- ***Extrusion.***

Extrusion is forming thermoplastic materials into pipes, tubes, sheeting, and rods, and also coating wire and cables. This work is



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Extrusion molding

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Mop-head fastener made of thermoplastic.

done by a machine in which the plastic material is simply placed in a hopper and comes out as the finished product.

The extrusion machine operates as follows:

1. The selected molding powder is placed into a hopper. This powder may be purchased in a particular color or it may be colored by using a drum tumbler, discussed in a later chapter.

2. The plastic powder goes down from the hopper onto a screw. This screw operates on the same principle as the screw in a coal stoker for a furnace.

3. The screw takes the plastic through a heated chamber where it becomes a liquid.

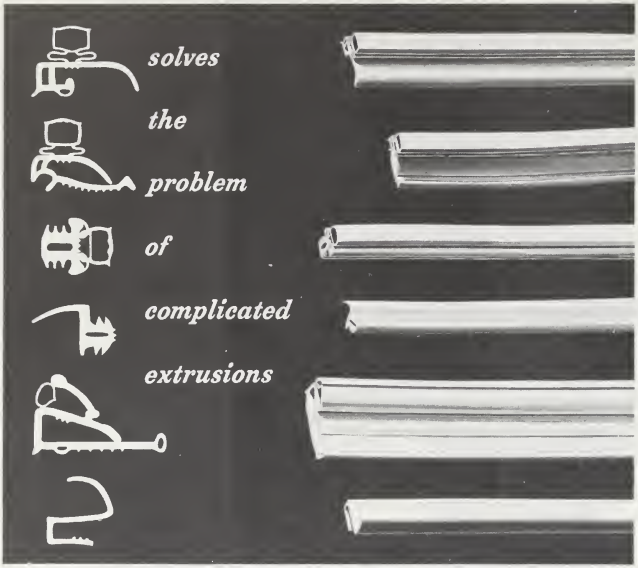
4. At the end of this chamber has been placed the die to form the item wanted.

5. The hot plastic is forced through this die as the screw turns. Then it goes out onto a conveyor belt where it is cooled by water or air. When pipe is made in this way, it may be cut off at pre-determined lengths or, at the end of the belt. An attachment may be used to arrange the pipe in rolls of some desired length.

Sheeting is made by splitting the tube as it comes out of the die, then pressing with rollers. The thickness is determined by the space between the rolls. In the sheeting product, cooling follows the rolling process.

- ***Calendering.***

Calendering is forming thermoplastic material into a continuous



GENERAL TIRE AND RUBBER CO.

Plastic items made by extrusion.

sheet with controlled thickness and surface finish. The plastic compound is passed between a series of three or more heated rollers and three or more cooling rolls. The speed of the calendering and the thickness of the material determines the number of cooling rolls needed. The rollers gradually squeeze the plastic into a sheet or film. The thickness is determined by the space adjustment between the rollers.

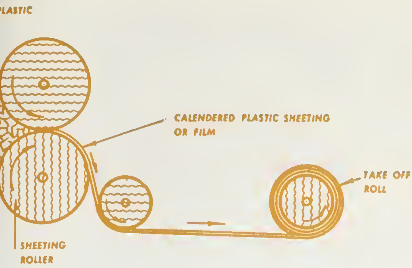
The rollers are powered by slow speed electric motors. Some are set up with a line shaft on one large motor. Others have individual motors for each group of rollers. The rollers are usually set up in groups of three.

Slow speed sheet calendering will usually have three cooling rollers, while others will have as many as nine. Cooling rollers are usually set up in groups of three for best speed control.

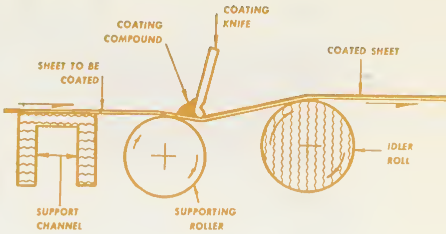
The procedure in calendering is as follows:

1. If a design is wanted on the material, as on leather or wood, it is etched on a heated roller.

2. The material may be purchased in the desired color or it may be colored by drum tumbling.



Calendering



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Coating

3. The rollers are set for the desired thickness.

4. The prepared plastic is placed into a hopper.

5. The material, in a paste or wax form, is fed by the machine between the first two heated rollers. The heat and pressure form the material into a sheet of uniform thickness. From the first two rollers the material is pulled down by the third roller and onto the next series used. The last roller is neither heated nor cooled, but used to roll the finished product.

Plastic coating is applied to the fabric and other materials by calendering. The plastic sheeting comes through two heated rolls. Beneath these, two more rollers are feeding the material to be coated. The hot plastic sheeting is then rolled on the material.

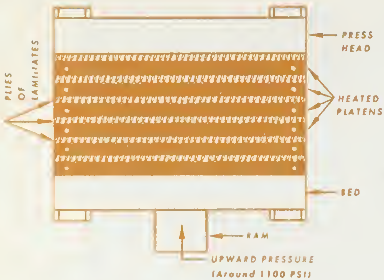
- ***Laminating.***

There are numerous methods of laminating plastic, each having its individual techniques. However, they come under two broad applications, high and low pressure laminating.

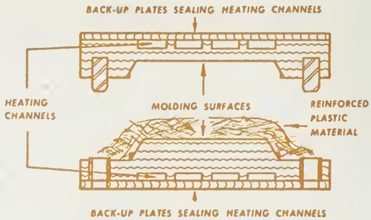
Thermosetting plastics are usually used with sheets of paper, fabric, asbestos, fiber glass, or similar materials, in *high pressure* laminating. These materials are coated with resin and placed together under heat and pressure. The coating may be applied by rollers, spray, dipping, or pouring.

These laminates are partly cured under heat in a drying oven and are removed when they have only partly polymerized. This leaves them in a condition to be cut and adhered together. Final polymerization is carried out in a press where the laminate is formed to some desired shape. If the laminate is to have a high finish, polished plates are needed. The press is to be equipped to heat the die of plates to a temperature of 270 to 350 degrees F. Usually the heating is done by steam.

Low-pressure laminating molds lend themselves to irregular shapes, such as boat hulls and aircraft wings. One of the least expensive yet suitable materials used in low pressure molds is



High pressure laminating



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Reinforcing

plaster of Paris treated with resin. Other molds are made from wood, sheet metal, and cast metal.

Thermoplastic laminating of documents, papers, or pictures may be done in an open mold, saturating with a plastic resin and curing at room temperature. However, the laminate can be produced with machines and polished steel molds.

An appliance knob made of thermosetting plastic.

PATENT BUTTON CO.

The *lay-up method* over an open mold is used in the forming of boats or mats, which will be discussed in a later chapter.

Bag molding of laminates is a process in which a bag is used to apply pressure against a lay-up while it cures. This process is done by vacuum or pressure.

For *vacuum molding*, the procedure is to lay-up the part to be molded in an open mold. Then a coarse fibrous material is placed over the lay-up. A gasket is placed on this material and the bag on top of the gasket. The fibrous material makes a space for the air to leak through. The bag is clamped down with a clamp or a clamping ring. A vacuum then draws the air from the laminate and brings pressure to bear on the laminated item.

Pressure rubber bag molding is similar to vacuum molding except

that a plate is substituted for the clamping ring. This provides a cover for the mold. The pressure is applied to the plate, forcing the air from the laminate. Curing may be by room temperature or by heat, depending on the plastic used in the laminate.

The *matched-metal die method* produces most reinforced plastic products. The procedure is to place the fabric to be used in the lower part of the mold and pour resin into the mat. The second layer of fabric is placed on the resin and more resin is poured on this fiber. The desired thickness determines the number of layers. The thickness also determines the space between the mold sections when closed. The working time of the lay-up is determined by the gel time, which may be made longer by reducing the amount of catalyst. However, this will increase the molding time.

A pressure of 100 to 150 pounds per square inch is usually adequate with a molding temperature of 220 to 250 degrees F.

- ***Forming thermoplastic.***

Thermoforming is a process in which sheets of plastic are heated and caused to conform to the contours of a mold .

There are several different techniques developed for forming thermoplastic. *Blow molding* is the method by which the material is heated in an oven and transformed to a forming press or jig and clamped. Air pressure is applied to force the hot plastic to the contours of the mold. *Controlled blow molding* is clamping hot plastic in a mold and forming press and applying enough air to blow the material into a bowl shape or bubble. When the plastic has been blown to the desired shape or size, the air pressure is cut off and the material remains clamped in the press until the plastic cools.

Vacuum forming is clamping heated plastic on a male mold directly above the female mold and applying a vacuum between. The air between the heated plastic and the female mold is removed, thus pulling the plastic down on the contours of the mold. The plastic is held in place by the vacuum until it is cool. After cooling, the finished item is unclamped and removed from the mold.

Drape forming is heating the plastic and allowing it to drape over the male mold to give it a pre-shape before applying the

Vacuum formed item.

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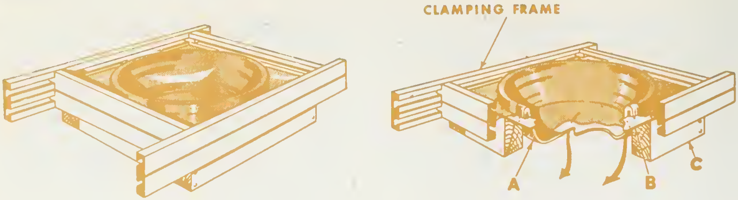


COMET INDUSTRIES

Vacuum forming mold.

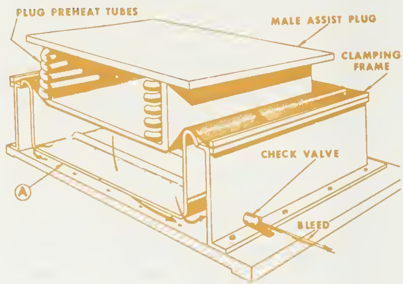
vacuum. This method gives more uniform thickness. After the pre-shape has formed, the plastic is clamped and a vacuum is applied.

Several different techniques have been developed to aid in vacuum forming such as plug assist, inverted drape forming, vacuum snap back, billow forming, and blow-up vacuum reverse.

Plug assist forming is a combination of cavity and drape forming. The plug prevents the material from becoming thin in deep drawn sections. The plug is heated and used to position the material into the cavity.

Inverted drape forming is used to eliminate plug mark-off and defects due to plug contact with the heated sheet of plastic. The plastic is heated until a sagging of the material appears. This method allows additional material for the corners, which will prevent the plastic from being thinner there.

Vacuum snap back is a process of predrawing of the plastic into an open end box by the use of vacuum. After the desired predraw the plug mold is placed into the box.

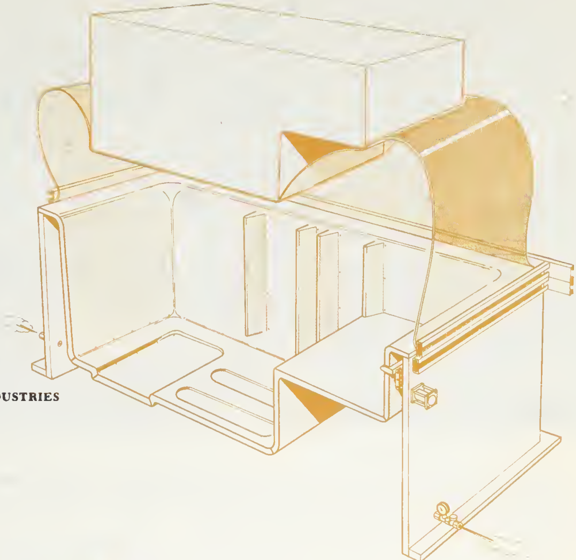


COMET INDUSTRIES

Plug assist forming.

Billow forming is the process of pre-stretching the plastic by regulated air pressure from a heated plug. This method is used in forming thin wall items with a deep draw ratio. Air is blown through the plug and through the mold, which forms a cushion of air for protection of the thin walls.

Blow-up vacuum reverse is blowing the plastic up from the female mold. This results in a thicker bottom and thinner side walls. The plastic is then vacuumed down into the female mold, assisted by pressure on the male mold.



Blow-up vacuum reverse into cavity.

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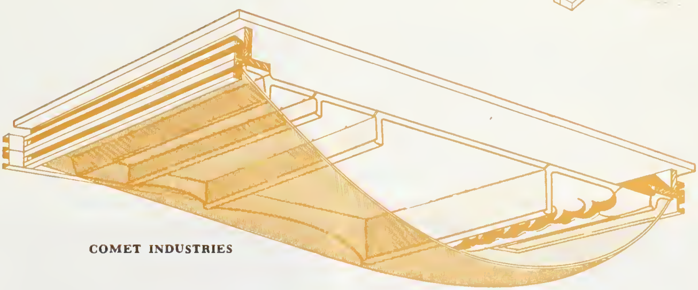

COMET INDUSTRIES

Inverted drape forming.

Working in the plastics industry requires much more skill than simply pushing buttons on a machine to produce plastic items. Many signs you see while traveling are products of a series of industrial procedures carried out by skilled hands. The illustrations on the next two pages will show you some of the work that goes into making a plastic sign, using the vacuum forming method in industry. Skills learned in the shop provide a basis for understanding and performing these industrial techniques.

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In industry after a plastic sign has been molded by the vacuum forming method, it is removed from the mold. Careful removal prevents straining the plastic.

Here the curved edge of a sign is trimmed and smoothed. Portable tools such as sanders, routers, and drills are used at this stage of sign production. The router is used for accurate shaping of the edge. The portable sander is used for smoothing the edge, and the drill is used to drill holes for assembly.

AMERICAN CYANAMID CO.

As a rule, molds require from one to three inches of excess plastic. A circle saw is used to trim a sign with straight edges, as shown in the illustration. An industrial worker must be able to set the saw to cut off the right amount and feed the plastic into the saw accurately. Clamps are used on the excess plastic to fasten it airtight while it is formed.

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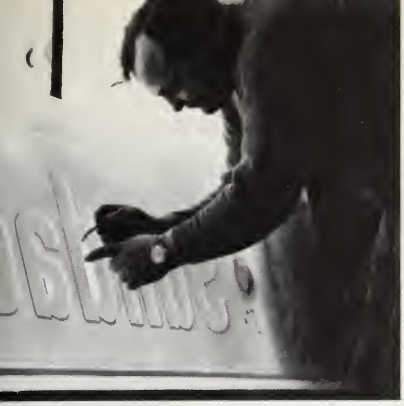

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Here part of the sign is taped in preparation for spray painting the plastic. The number of different colors to be used on a sign determines the number of taping and spraying operations required.

AMERICAN CYANAMID CO.

Now the spray paint is applied. The worker must know what colors will be used and in what order. He must also know how to operate and care for a paint sprayer. In addition, workers must be familiar with the properties and preparation of paints which are used on plastics.

Questions on Processes

1. What are the three major types of industries working with plastic?
2. How many pounds of plastic were produced in 1942?
3. How many pounds of plastic were produced in 1961?
4. What are the principal methods of processing plastic?
5. As a rule, what kind of plastic is used for compressed molding?
6. What is compression molding?
7. What are the three main factors in compression molding?
8. What determines the strength of the finished article made by compression molding?
9. What is the difference between compression molding and transfer molding?
10. What kind of plastic is usually used for injection molding?
11. What is the main difference between the compression mold and the injection mold?
12. Why is it possible to use the excess parts from an item made of thermoplastic?
13. What kind of plastic is used for blow molding?
14. What are some of the items made by blow molding, using molding compounds?
15. Why is a mold for blow molding made in two sections?
16. In blow molding, what is used to force the plastic into the mold?
17. What are some items made from dip molding?
18. What are some items made by extrusion?
19. What is plastic calendering?
20. How is a design, as for leather or wood, made in plastic calendering?
21. What is the difference in high pressure and low pressure laminating?
22. What is drape forming?
23. Why is a plug used in vacuum forming?
24. What is vacuum snap back?
25. What is billow forming?

3 MEASURING AND MARKING

Plastic materials for use in the shop usually come covered on both sides with masking paper for protection of highly finished surfaces of the material. This protective paper also makes it possible to mark off pieces of any desired bill of materials, and makes possible the transfer of designs by use of carbon paper.

One objective of all industrial arts courses is to teach economy. The methods of marking off pieces of a bill of materials should be such as to produce the least possible waste. For example, select the smallest piece of material from which a particular part can be cut, and that piece should be measured in such a way as to leave waste which could be used in some other smaller part.

In marking and measuring allow for saw chips and sanding. For example, if a piece of material 2″ in width is wanted, the marking off should be 2¹⁄₁₆″. The extra ¹⁄₁₆″ will be used up in sanding out the saw chips.

Take care at all times not to disfigure the plastic under the masking paper. Much work and time can be saved if this finish is not scarred in any way. Careless handling on the work bench, near sharp-pointed tools, will almost certainly lead to scratches on the finished surface of the plastic. Also scars might be made by the careless or improper use of tools, such as the compass. If care is not taken, the metal point of the compass might go through the masking paper and scratch the material.

In storing unused material, take care to place it back in the storage rack so as not to damage it or any other material in the rack. Place all unused material

Measuring and marking plastic covered with masking paper.

back in storage as soon as the materials have been cut out, so as to get it out of the way of other workers and to protect the material.

Material of a thickness of 2″ to 3″ may be obtained without masking paper on it. This *might not* have a finished surface. Any one of several ways may be used in marking this material. *One* is to cover it with masking paper that has been taken from other material. *Another way* is to scratch the marking on with a sharp-pointed tool such as a knife, scratch awl, or a divider. *Probably the best method* for making a straight mark is to use a straightedge and a sharp-pointed tool.

Quite often *it may not be necessary to mark the material at all,* but simply set the saw fence so as to cut the desired size. If several pieces 1″ in width are desired, set the saw fence 1¹⁄₁₆″ from the saw blade and leave there until all pieces are cut.

Measuring and marking unmasked plastic using a try square and scratch awl.

Questions on Materials

1. Why is the masking paper on the plastic?
2. What method should be used in marking off the pieces of a bill of material?
3. How much allowance is made for saw chips and sanding?
4. What might be expected from careless handling of plastic?
5. What should be done with unused material?
6. How can one mark off the pieces of a bill of material on plastic that does not have masking paper?
7. When can one make plastic cuts without marking on the material?

4 SAWING WITH POWER TOOLS

Four power saws are used in the shop: the circle saw, the jig (or scroll) saw, the band saw, and the hole saw. They will be treated in this order.

- *Circle saw.*

There are precautions which should be taken before starting to use the circle saw:

1. Have the proper blade on the saw.
2. Understand thoroughly the method of using the saw.
3. Learn to adjust the saw to the proper height above the table top.
4. Learn how to adjust and set the fence so as to cut the correct size.
5. Learn how to use the T-guide so as to assure safety and the proper cut.
6. Know how to grease and oil the parts of the saw.
7. Practice all safety rules so as to protect yourself and other workers.
8. Finally, before starting to saw, be sure you have the correct dimensions for the cuts you want to make.

Blades with carbide tips are recommended for the plastic shop having a large amount of material to be sawed. The teeth on this saw are designed so that they alternately start and finish the cut. The teeth are diamond-ground, so the saw should be returned to the factory for regrinding when it is dull. Acrylic plastic is a thermoplastic; therefore dull saws will heat the plastic, causing an uneven saw joint.

Carbide grit cutting and sanding wheels are recommended for those who do not cut enough plastic to justify the purchase of a carbide blade.

The standard hollow ground blade used in wood shops may be used for cutting plastic. An 8 inch blade with from 5 to 7 teeth per inch is good. The teeth should have uniform height and be of the same shape. This is to prevent chipping and uneven cutting.

The manufacturers of the circle saw, like the manufacturers of automobiles, make them differently. Therefore a thorough knowledge of how to operate the particular saw to be used is needed as well as knowing the properties of the material to be sawed. To understand how to operate the saw, one must know how the guard works and how to adjust the blade to the proper height. The height of the saw blade above the table is to be set a little more

R. HOE AND CO., INC.

Carbon grit saw blades.

than the thickness of the material to be sawed. When sawing thick material about ¼ inch extension is needed. The knowledge of how to use the T-guide, how to use the fence, how to grease and oil the parts of the saw, and how to set the saw to the proper angle is also needed.

Practice all *safety rules* so as to protect yourself and other workers.

Learning to use a saw safely, like learning to drive a car, is important. It must be done with caution. Every boy wants to learn to drive, but he must realize that driving demands care.

The same is true of the saw. It will saw plastic, or it will saw a finger. So a worker must learn how to put the plastic to the saw and keep his fingers clear. He must use the right size pieces, firmly held. It is just that simple, but, as in the case of driving, it requires constant care.

Observe all posted *safety notices.*

As a rule there are *gages* on saws by which to set the desired height of the blade and the desired spacing of the fence. However, it is a good practice to double check the accuracy of these settings by measuring after the saw has been set.

Oiling and greasing instructions are given by the saw manufacturer. These instructions should be followed carefully.

WARNING: Before turning the

Another view of the circular saw showing guard and paper covering.

saw on, be sure that all other persons are at a safe distance—at least 3 feet away from the saw. It is good practice to mark a *safety zone* around the saw. When using the saw, wear *goggles* to protect the eyes from chips of plastics. Paper-coated plastic helps control flying chips.

Always use a *pusher* when sawing a narrow piece which cannot be held with the hands safely.

When using the fence, set it so that the piece of material will be between the saw and the fence,

Cutting plastic with bench or circular saw, using a pusher.

and the waste, or unused part, on the other side of the saw blade. As a rule, a right-handed person can use the saw best with the fence on the right of the saw blade, and a left-handed person, with it on the left side. Push the plastic all the way through between the saw and the fence and then bring it around the fence or over it. If the sawed piece is brought back along the saw, it will mar the edge.

Warning (1): To be safe, never pick up small pieces from the saw table while the saw blade is running. Remove waste only after the saw blade has been stopped. There is grave danger of contacting the moving saw blade if you try to remove material while the saw is running.

Warning (2): In feeding the plastic through the saw, do not force it. This will cause damage to the plastic and the saw blade from overheating. If a melted ridge accumulates while sawing, the plastic is being fed too fast. Coolant (a 10 percent solution of soluble oil) directed on the blade is used to help prevent overheating, when sawing thick material.

Warning (3): As the plastic is fed into the saw, pressure should be applied on one side only. If it is applied on both sides, there is danger either that the saw will bind or will throw the plastic toward the operator's face. If the fence is being used, apply the pressure on the part between the saw blade and the fence.

Warning (4): When using the T-guide, push the fence back out

of the way, or even remove it if necessary, so it does not interfere with the use of the guide. Often it can be left on the saw and still be out of the way, but the operator should be sure it will not interfere with his sawing. As a rule the T-guide is better used on the left of the saw blade, with the larger section of the material against the T on the left side. This makes it possible to keep both the T-guide and the fence on the saw table most of the time. The plastic is fed to the saw by pushing the T across the saw table.

WARNING (5): Use the saw guard on the saw at all times if possible, but in the handling of some plastic cuts, due to their size, it is necessary to remove the guard. (This is different from general shop practice, as in wood, where the guard is always used.) This condition makes safety care of very great importance.

Remember to observe all safety rules strictly when using the circle saw. Set the saw blade at the proper height for the material to be sawed and feed the plastic into the saw slowly, so as to be sure of getting an accurate, safe cut.

There should be designated places for storing leftover materials from the saw, and the operator should take the responsibility for putting away all these leftovers after he has sawed out his materials. Also the saw blade should be run back down under the saw table when the sawing is finished.

Table 1

SPEEDS FOR CUTTING WITH CIRCLE SAW, AT 1725 rpm

Thickness of Material (inches)	*Speed of Feeding (seconds per inch)*
3	8
2½	7
2	6
1½	5
1	4
½	2
$\frac{3}{16}$–$\frac{1}{16}$	1

Questions on the Circle Saw

1. Name three types of circle saw blades that are used for cutting plastic.
2. What precautions should be taken before using the circle saw?
3. Why are there gages on the saw?
4. How high should the saw blade be above the table top?
5. How far away should others be while the circle saw is in use?
6. Why wear goggles while operating the circle saw?
7. When should a pusher be used while sawing?
8. What could happen if the operator should feed the saw with pressure from both sides?
9. When should the small waste pieces be taken off the saw table?
10. What will happen if the plastic is fed too fast?
11. What is evidence that thin plastic is being fed too fast?
12. In feeding the saw, where should the pressure be applied if the fence is being used?
13. What are the results of overheating while sawing?

- *Jig saw (or scroll saw).*

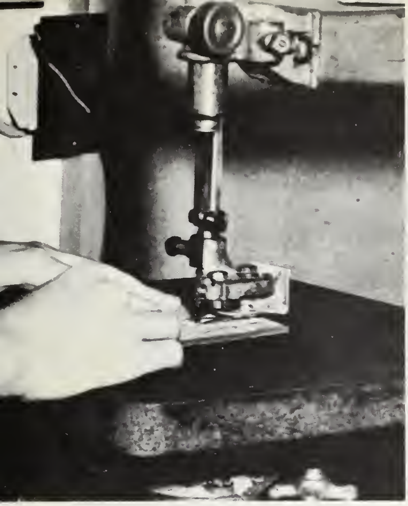
The most common use of the jig saw in the plastic shop is for cutting inner portions out of a piece of material. This is done by first drilling a hole in the waste part of the plastic, large enough for the saw blade to enter. The blade is then released at both top and bottom chucks of the saw. The plastic is placed on the saw table with the hole in line between the two chucks. Then the blade is placed through the hole in the plastic and fastened back into the saw chucks.

A metal cutting jig saw blade is recommended for cutting plastic. A sharp blade is to be used at all times to avoid heating the plastic. If you attempt to saw plastic with a dull saw, the saw will heat and cause the plastic to fuse.

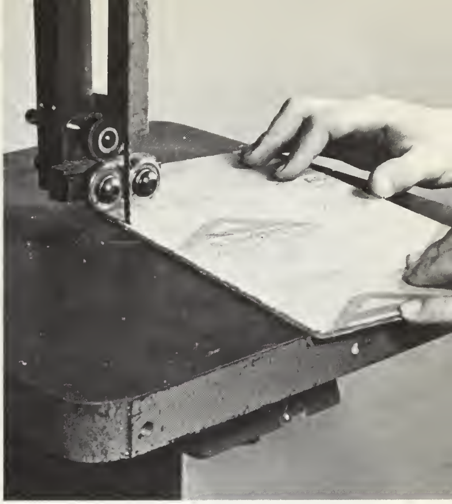
The thickness of the plastic will determine the procedure to be followed while sawing. For example, if a piece of material ⅛ inch in thickness is to be sawed, the plastic is fed into the saw blade at a steady, slow rate of speed, without coolant. If a piece of material 1 inch in thickness is to be sawed, a coolant is used. A good coolant is a 10 percent solution of a soluble oil. While sawing 1 inch plastic, it is also necessary to adjust the saw to a slow rate of speed. Feed the plastic into the saw slowly and back out slightly if the blade appears to be heating. Otherwise the plastic will fuse.

Before starting to use the jig saw, take the following precautions: (1) Check to see that the blade is in the machine so that the teeth are pointing downward. If the teeth are pointed upward, they will have a tendency to push the plastic up against the guard, causing the material to move up and down while sawing. This will make it difficult to saw accurately and might break the plastic. (2) Turn the saw one revolution by hand to check the blade before turning on the motor. If the blade bends while the saw is being turned this one round, the blade adjustment is wrong. Then it will be necessary to move the chucks closer together so as to enable the saw to go around and still keep a straight blade. If, while attempting to turn the saw around by hand, there seems to be a lock, that means that the chucks are too close together. Loosen and move one of them so that they will be farther apart. This is not a problem with jig saws which use pin end blades. However, it is necessary to keep blades the proper length in jig saws, and they cannot be used after breaking. (For the saw that does not require pin ends, the blades can be made from old band-saw blades or broken coping saw blades.)

After you are ready to saw to the desired design, place the plastic on the saw table and adjust the guard so that you can feed the material into the blade with no more than $\frac{1}{32}$ inch up-and-down movement. Clean the saw table before starting, to be sure the



Cutting plastic with a jig saw.



Using the band saw on plastic.

plastic is level and to prevent scarring.

In feeding the plastic, keep in mind the thickness of the material you are sawing, and feed accordingly. If the plastic is 1/16 inch the saw will cut it much faster than if it is 1/8 inch. Both hands should be on the plastic, holding it flat on the saw table as it feeds into the saw, putting pressure with one hand or the other as the turn requires.

If you feed the plastic into the saw too fast, the blade will break or come out of the chuck. It is also hard to follow the cut-out line if the plastic is fed too fast.

As a rule the waste from a jig saw is less than from other saws, but a container should be close by in which to save this waste for use in making small projects such as sets for rings, backs for ear screws, key chains, etc.

Questions on the Jig Saw

1. What is the most common use of the jig saw in the plastic shop?
2. What kind of a jig saw blade is recommended for cutting plastic?
3. What is a good coolant?
4. When is it recommended that a coolant be used?
5. Which direction should the teeth point when the blade is in the jig saw?
6. What will happen if you saw with the saw teeth pointing up?

• ***Band saw.***

The band saw may be used for either curved or straight cuts. Metal cutting blades or fine-tooth wood cutting blades are used for cutting plastic. Metal cutting blades stay sharp longer. However, it is recommended that these blades be discarded when they are dull. Wood cutting blades can be resharpened.

The speed of the band saw should be set for slow speed when cutting material ½ inch or thicker, and to a fast speed when cutting thin material, less than ½ inch. The width of the saw blade needed is determined by the type of cuts. For straight line cuts or for a large radius, a wide blade is used. For a radius 3 inches or smaller, a narrow blade is used.

The blade is set with just enough tension to keep it on. The guide rolls and back up rolls are kept adjusted to give maximum support at all times. The upper guide is adjusted to within ⅛ inch of the plastic. This guide also serves as a guard for the worker.

Sawing a hole in plastic using a hole saw in the drill press.

The band saw is a machine with a thin rotary blade which goes around two wheels (or three, depending upon the type of saw). Being narrow and thin, the blade is easily broken. The saw is equipped with guards, making its operation only slightly dangerous, if operated from the proper position, directly in front of the saw teeth.

Warnings: People standing around the saw may be in danger; so a three-foot safety zone should be marked off around the saw.

Make these preparations before using the band saw:

1. Have the desired pattern marked off on the plastic.

2. Have the proper type of blade on the saw—that is, a fine-tooth saw blade with a small amount of set in it.

3. Clean the saw table of all waste to prevent scratches and to allow the plastic to rest firmly on the table.

The blade will saw plastic 1 inch or thinner fast (about 1 inch per second); however, if very sharp turns are required, they must be made slowly and with care to prevent the blade from binding and breaking, and to be sure the proper cut is made. Often it is necessary to saw a short distance and back off slightly, for material 3/16 inch or more in thickness, to make a sharp turn. The speed of feeding should be cut down proportionally as thicker material is sawed, or about 1 inch

per second for material 1½ inch or more in thickness. See Table 2.

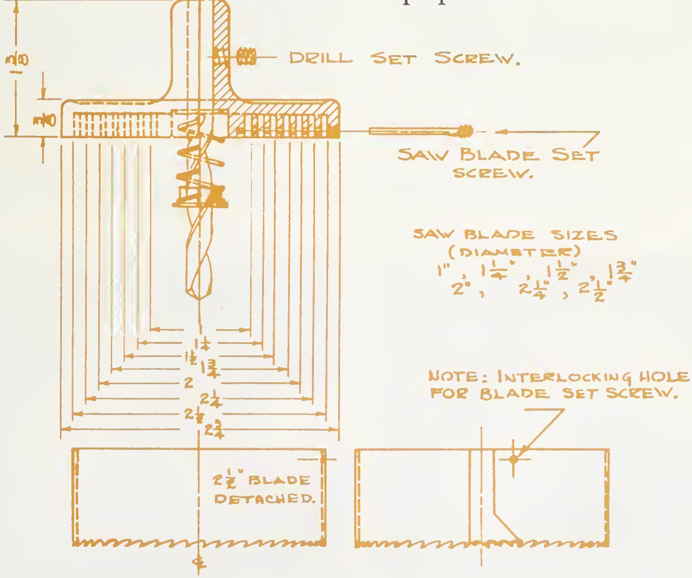
Drawing of the hole saw.

Table 2

SPEEDS FOR CUTTING WITH BAND SAW
(SPEED OF MOTOR WILL VARY
WITH LENGTH OF BLADE)

Thickness of Material (inches)	*Speed of Feeding (seconds per inch)*
3	4
2½	3
2	2
1½	1
1$\frac{1}{16}$	½

Keep both hands on the plastic while feeding it into the saw blade, in the proper position to enable you to hold the plastic firmly on the table and at the same time be able to turn the plastic to the desired position to assure the proper cut.



Questions on the Band Saw

1. What is the advantage of a metal cutting band saw blade?
2. Where should one stand while using the band saw?
3. What thicknesses of plastic may be sawed on the band saw?
4. How should sharp turns be made?
5. How fast will the band saw cut 1 inch material?
6. How should one hold the plastic on the band saw table?
7. What speed adjustment should be made for cutting thin plastic?
8. How far above the plastic should the upper guide be placed?

- ***Hole saw.***

Fundamentally, a hole saw is a metal tube with teeth filed on one end and a shaft fastened to the other end. A *pilot drill* and guide are provided in the center of the tube. The pilot drill is to enable the craftsman to locate and center the hole saw. A *plug* with different-size diameter grooves is provided to enable the workman to saw out different size holes. *Knock-out holes* are in the top for removing the saw discs. Like other saws the teeth have a set wider than the thickness of the wall. This is to prevent binding.

This saw is used in a drill press by fastening the shaft in the chuck and adjusting the speed from 1,100 to 1,750 rpm. It is used for holes larger than can be made generally by available drills. The saw comes in sizes from 5/6 to 4 inch diameter. See pages 50 and 51.

Questions on the Hole Saw

1. What machine is used to power the hole saw?
2. What is the proper speed for using the saw?

5 MACHINE SANDERS

The sanding machine is slow-speed, 1,100-1,725 rpm. It may be a belt, a disc, or a drum type. Also there are combination belt and disc sanders. Vibrating types of sanders are available. But in the plastics shop the two kinds generally used are the moving belt and and the turning disc.

• ***Belt sander with disc attachment.***

As said, the belt sanding machine may have a disc sander attached to it. The disc attachment is made of metal. A special adhesive is used to fasten sandpaper to the disc.

To glue sandpaper on, first clean the disc with a screw driver. This is done with the machine running at its normal speed. The adhesive is then applied by holding the stick to the metal disc as it turns. Care is taken to get a uniform coat of adhesive on the metal. The motor is then turned off and adhesive is applied to the back of the sandpaper. The paper is then placed firmly onto the metal disc and the sander is ready for use.

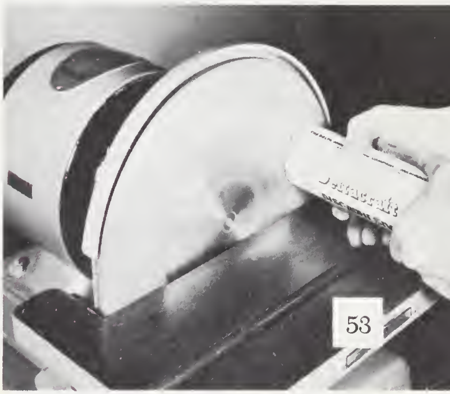
• ***Using the belt sander.***

The belt sander may be used in an upright position or running

Step one in gluing sandpaper on a metal disc, and showing how to clean the metal disc.

ROCKWELL MANUFACTURING CO.

Step two in gluing sandpaper on a metal disc, and showing how to apply the disc adhesive.



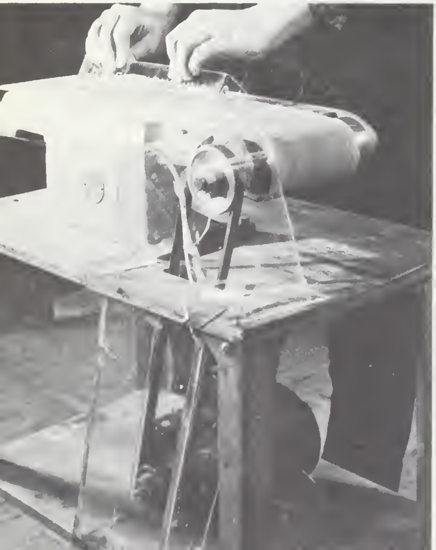
ROCKWELL MANUFACTURING CO.

STEP THREE in gluing sandpaper on a metal disc, and showing how to place the sandpaper on the disc.

STEP FOUR in gluing sandpaper on a metal disc, and showing how to clean the metal disc.

parallel to the floor. When in an upright position, a table enables the operator to sand angles and chamfers correctly. When many items are to be sanded to the same size and shape, jigs assure accuracy.

Sanding a desk name plate using a belt sander. Also showing a guard made of plastic.



The belt sander is used running parallel to the floor to sand such projects as a desk nameplate. This enables the operator to sand the plastic to the angle desired as well as keeping the nameplate level. Inside arcs are sanded on the ends of the sander as the belt moves around the rollers. Care must be taken to move the plastic around so as to wear the sanding belt evenly. If the operator should sand sharp edges in the same portion of the sanding belt and apply heavy pressure, the belt will soon wear out in that place.

- *Making disc sanders.*

The disc sander is powered by a ½ hp electric motor with 1,100-1,725 rpm. The disc may be made of ½ inch plywood, 8 to 10 inches in diameter, which is fastened onto a faceplate that is attached to the motor spindle.

Keep extra wood discs fitted with sandpaper on hand so that a sander may be changed without loss of time. Sandpaper glued onto wood discs must dry in clamps at least twenty-four hours before using. Use of a sander before this drying period might cause the paper to come loose from the wood. When the sandpaper is worn out, a new piece may be glued on the old without removing it from the disc, using a light coat of glue. If too much glue is used, it will soak through the new sandpaper and cause it to sand unevenly. The assembly is laid face down on a level surface and clamped so that the paper is pressed on uniformly.

• *The Sander-Grinder.*

The sander-grinder is a narrow belt machine used to grind metal, wood, or plastic. The machine's one-inch-wide belt enables the worker to sand irregular curves evenly. Small areas and difficult spots which other machines can't handle can also be sanded. For example, the inside of the letter O can be sanded by removing the belt, positioning the letter on the machine, and then replacing the belt. Narrow parts or corners, as in the letter A, can be sanded in similar fashion.

• *Drum sanders.*

Drum sanders may be made to use on the lathe or on the drill press. Sanders for the lathe are 6 to 8 inches in length and 2 to 3 inches in diameter. The drums are made of soft wood by turning them to the desired size. Then a slot is cut out lengthwise, ½ inch in width and ¾ inch in depth. Sandpaper of the desired grade is then put around the drum and overlapped in the groove. A piece of wood is cut to fit into this groove and fastened with flathead wood screws. The screws are

Gluing sandpaper on disc sanders.

Using the sander-grinder to sand inside the letter O.

Using the machine disc sander.

Fastening the wedge on the drum sander for the lathe.

countersunk so as to keep the heads from touching the material in the sanding operation. The wood wedge is the size of the groove minus twice the thickness of the sandpaper. If the wedge does not screw down level with the drum surface, it must be filed down with a wood file.

The drum sander for the drill press is made from a ½ inch dowel and should be about 5 to 6 inches in length. This sander is used on small inside curves, while the drum sander is used for larger inside curves. Sanding of other surfaces is done on the disc or belt sander.

Questions on Sanders

1. What are the different types of sanding machines?
2. At what speed should the disc sanders run?
3. What is the drying time in gluing sandpaper to the wood disc?
4. Why should a thin coat of glue be applied in the gluing of the sandpaper to the disc?
5. What is the best size for the drum sander to be used on the lathe?
6. How is such a drum sander made?
7. What is the size of the drum sander to be used in the drill press?

- ***Selecting sandpaper.***

When using a circular sander, select one with the proper grit of sandpaper for the job to be done. Sandpaper is called *coarse, medium,* or *fine*, depending upon the size of the grit. If the grit is large the paper is called "coarse" sandpaper. If the grit is smaller the paper is called "medium." And if the grit is quite small the sandpaper is called "fine."

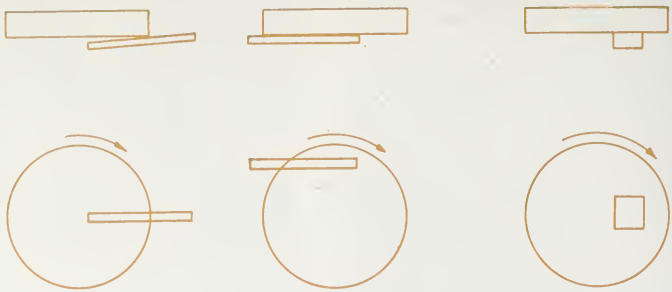
Sandpaper sizes are called No. 1, No. 1/2, No. 1/0, No. 2/0, etc., going from coarse to fine. The No. 1 is a coarse paper. No. 1/2 is half as coarse. No. 1/0 is still finer and No. 2/0 is very fine sandpaper. (Or rough grit is 80 to 120 per square inch. Fine grit is 320 to 400 grit per square inch.)

Before starting to sand a piece of plastic, select a sander equipped with sandpaper of the proper grit. This selection of the proper sandpaper will depend upon the condition of the material and upon how much is to be sanded off. For example if the material already has the correct shape and size, and only small streaks remain, choose a fine sander. If the plastic is way oversize and wrong in shape and must be put into the correct shape and size by sanding, then a coarse sandpaper should certainly be used. If a fine sandpaper is used to do a large amount of cutting so as to get material in proper shape, the sandpaper will be ruined and the plastic burned. And still the plastic will not be sanded properly. A large amount of sanding is necessary when the material has deep gaps or very rough places to be removed, such as rough places often left by saws. Coarse sandpaper is also needed to sand chamfers on blocks or to take deep streaks out of the plastic.

WARNING: The proper use of the sander is very important from the safety standpoint as well as in shaping and smoothing the material. When a machine equipped with a disc sander is turned on, note which direction the sander is turning, and work on the half of the sander which is *going down.* Dust coming from the down-turning side will go down onto the floor. The up-turning side of the sander will throw dust into the operator's face and eyes, and plastic dust is not pleasant to the eyes. If dust should get into the eyes, rinse out with diluted boric acid or other eye solution at once.

- ***Position.***

The position at which a piece of plastic is held against the sander depends upon the type of sanding wanted. For example, when sanding a round stem from a square piece, sand off the corners, using the outer edge of the sanding disc about halfway down. After the corners have been thus removed, the plastic is then held near the top of the sander and rolled until the rounding is completed. However, if one wishes to smooth a small piece of plastic on the fine sander, he should hold the material lightly against the sander about halfway down.



Positions for sanding on a disc sander.

To sand a surface for a glue joint, use a medium sander, put the material lightly against the sander, and pull it straight off. This should produce a level surface, which is necessary for a good glue joint. But if it is found that the surface is not level when tested by a straightedge, the operation is repeated. (Medium sandpaper is used for this operation because actual practice has shown that fine sandpaper will not leave a level surface. If coarse sandpaper is used in this operation, deep streaks are cut into the plastic, making gluing unsatisfactory.)

- *Burning.*

Burning of the plastic is caused by one of two things: either too much pressure is applied or the sandpaper being used is too fine. If there is a white substance on the surface being sanded, the plastic is burned. It is always a good practice to move the plastic around on the sandpaper to help prevent heating. If the plastic tends to "bounce" off the sander, too much pressure is being applied. The desired shape determines how the plastic should be moved about on the sander. In sanding for a glue joint, the plastic is moved from one part of the sander to another, holding the plastic level. In rounding or shaping a piece, such as a ring, turn the plastic in a circular movement.

Coarse sandpaper cuts so fast that it can be used for *cutting chamfers* or *rounding curves* more easily than a saw. However, before sanding in this fashion, mark the desired amount to be removed. Otherwise too much or too little might be removed.

Whenever a *level surface* is desired, check the material often with a straightedge.

WARNING: Perfect results can-

not be expected in these operations without much practice and great care. Even a shoe-shine boy does not become expert at his work in a few weeks' time, or without perfective practice. He must develop his technique and practice it a long time before he can put a real shine on a shoe.

Questions on Sanding

1. What is the difference between fine, medium, and coarse sandpaper?
2. How are the grades of sandpaper numbered?
3. What kind of a sanding disc should be used in shaping a piece of plastic when a large amount is to be sanded off?
4. On which half of the disc sander should the plastic be held?
5. With what tool should one check to see if he has sanded level?
6. What will cause the plastic to be burned while using the machine sander?
7. What causes the plastic to "bounce" off the disc sander?
8. How should the operator hold the plastic on the disc sander when sanding for a glue joint?
9. What is it necessary to do in order to do excellent work with the sander?

6 THE BUFFING MACHINE

• *Buffing plastic.*

Buffing is a machine process by which a high polish is put on plastic. It is necessary that the plastic be in the proper condition before buffing, and, as just discussed, it is put into proper condition by *sawing, machine sanding, scraping,* and finally *handsanding.* If a worker goes to the buffer before any of the above operations is properly done, he is wasting his time and effort. In other words, when a piece of plastic goes to the buffer, it should be in its final form and free of all streaks, so that when the buffing is finished the worker has a highly polished, finished product.

The buffing machine may be equipped with cloth buffers connected to an electric motor shaft by the use of a work arbor; or the buffers may be assembled on a line shaft.

The speed of the electric motor used on the line shaft may be 1,100 rpm to 3,400 rpm, since the correct shaft speed can be obtained by using a small pulley on the motor shaft and a larger pulley on the line shaft. The best speed for the line shaft is 1,100 rpm to 1,400 rpm.

The shaft may be any length, with buffing wheels set at least 12 inches apart. The diameter of the cloth buffs should be 12 to 14 inches. On a line shaft with 20 to 24 wheels, it is best to have two cutting wheels to one polisher. This is true because more time is required on the cutting wheels than on the polishers. The difference between the cutting wheel and the polisher is that buffing compound and wax are put on the cutting wheel but nothing at all is put on the polisher. Some cutting wheels have been made of felt, but these proved unsatisfactory for amateurs, because it was found that the felt heated the plastic too quickly.

If the buffing machines are made up by connecting the work arbor to the motor shaft, the speed of the electric motor is 1,725 rpm. And the motor should be the type which has a shaft on each end. This will make a complete buffer, with a polishing wheel on one end and a cutting wheel on the other. With a speed of 1,725 rpm, the best size of wheels is 8 to 10 inches in diameter and 2 inches in thickness. However, for the sake of economy, the wheels should be used until they are

worn down to 3 to 4 inches in diameter. The plastic should be held on the wheel in such a way that the wheel will wear down evenly.

Cloth buffers are made of discs of cotton cloth sewn together close to the bore, but left loose at the circumference. This section contains about ten discs of cloth, and about five sections make a good buffer.

The so-called wax used on the cutter is nothing more than paraffin, bought under the trade names of Tex-wax, Esso-wax, etc. (Industry generally uses tallow, but use of tallow is not advisable for the amateur because he has a tendency to keep too much on the wheels. And besides, paraffin serves the purpose just as well as tallow.)

Questions on the Buffing Machine

1. What is the best speed for a line shaft buffer?
2. How far apart should the buffing wheels be spaced on a line shaft?
3. Why should there be more cutting wheels than polishers on a line shaft?
4. What should be the speed of the electric motor when the buffers are connected on the motor?
5. What is the attachment that is used to connect the buffers onto the electric motor?
6. What should be the diameter of the buffer used on an electric motor with 1,725 rpm?
7. What should be the thickness of the buffing wheels?
8. Why should wheels be used until they are worn to 3 to 4 inches in diameter?
9. What is the difference between the cutting wheel and the polisher?
10. Why are cutting wheels made of felt not used in the school shop?

- ***Cutting.***

The cutting wheel must have *buffing compound* and *wax* on it at all times. The *buffing compound* helps to do the cutting, removing all the small streaks that have been made by the handsanding process. The *wax* keeps the buffing compound on the wheel and helps keep the plastic cool during the buffing process. (The wax, however, will not keep the plastic cool when the buffer is used to remove streaks which should have been removed by sanding. An attempt to buff out such streaks by applying more pressure and spending more time in buffing will heat the plastic too much, but the damage done in this way will not appear until several months later, when cracks appear—sometimes as deep as ¼ inch.)

To apply buffing compound and wax, stand in front of the wheel with the wheel turning downward. Hold the wax on the wheel until the wheel has turned about eight turns. The buffing compound is held on the wheel until the wheel has turned around ten turns. This process is repeated often to keep the proper amount of compound and wax on.

WARNING: If buffing compound and wax are not kept on the

wheel, the wheel will soon wear out, and also burn the plastic.

Work in front of the wheels at all times when buffing, holding the plastic on the wheel where it *starts under,* if possible, when buffing small pieces. NOTE: There are times, in buffing large pieces, when it is necessary to use the top of the wheel, but there is no danger that large pieces will be thrown from the buffer. In buffing a small cube, hold the cube on the wheel at all times so that the wheel doesn't touch a corner first. If it does, it will pull the cube into the wheel and throw it away from the buffer. For this reason, the buffing machine should be placed in the shop in such a way that if and when an operator allows the buffing wheel to throw his plastic, it will not endanger equipment or other persons.

Move the plastic around on the wheel slightly, which will prevent the wheel and the plastic from getting too hot. While the plastic is being applied to the cutting wheel, it will be cloudy, and often the cutting may not appear to be doing any good. This cloudiness is caused by the buffing compound and wax on the plastic. It is hard to say how much time or pressure should be used on the cutting wheel. Several factors determine that: (1) the condition of the plastic, (2) the size of the plastic, (3) the shape of the plastic, and

Buffing plastic.

(4) the speed of the wheel. However, as a rule, you can complete the cutting wheel process on a small (about 3 by 3 inch) cube in about one minute for each surface, applying about 3 pounds pressure. Put less pressure on smaller pieces and more on larger ones.

Strive at all times to keep the corners out of the wheel. This can be done by moving the plastic around.

- ***Polishing.***

After you are through on the cutting wheel, hold the plastic on the *polishing wheel* in the same manner, except with a very light pressure, about ⅓ as much as on the cutting wheel, moving the plastic around faster. This is done to keep the plastic from getting hot while removing the buffing compound and wax, which was applied to the plastic while using the cutting wheel. *Buffing compound and wax are never applied to the polishing wheel.*

The work of the polishing wheel will greatly impress you, for you see the high polish appear on the plastic for the first time, and are delighted. However, high polish is not merely the effect of this one process, but is the result of all the work that has been done up to this point.

WARNING: It is hard to realize this; you think that the polisher has done it all. So you may be tempted to hold the plastic on the polisher too long, with the result that your plastic will become cloudy instead of having a higher polish, due to the fact that the wheel heats the plastic.

- ***Solvent polishing.***

There are times when the operator is unable to use buffing wheels for polishing. For example, the inside of an article with a triangular shape or the holes inside a salt or pepper shaker lid. To polish these inner surfaces by solvent, merely apply ethylene dichloride with a brush. Be careful not to allow the solvent to get on the outer polished surfaces, which would be marred. Solvent gives an appearance of a polished surface.

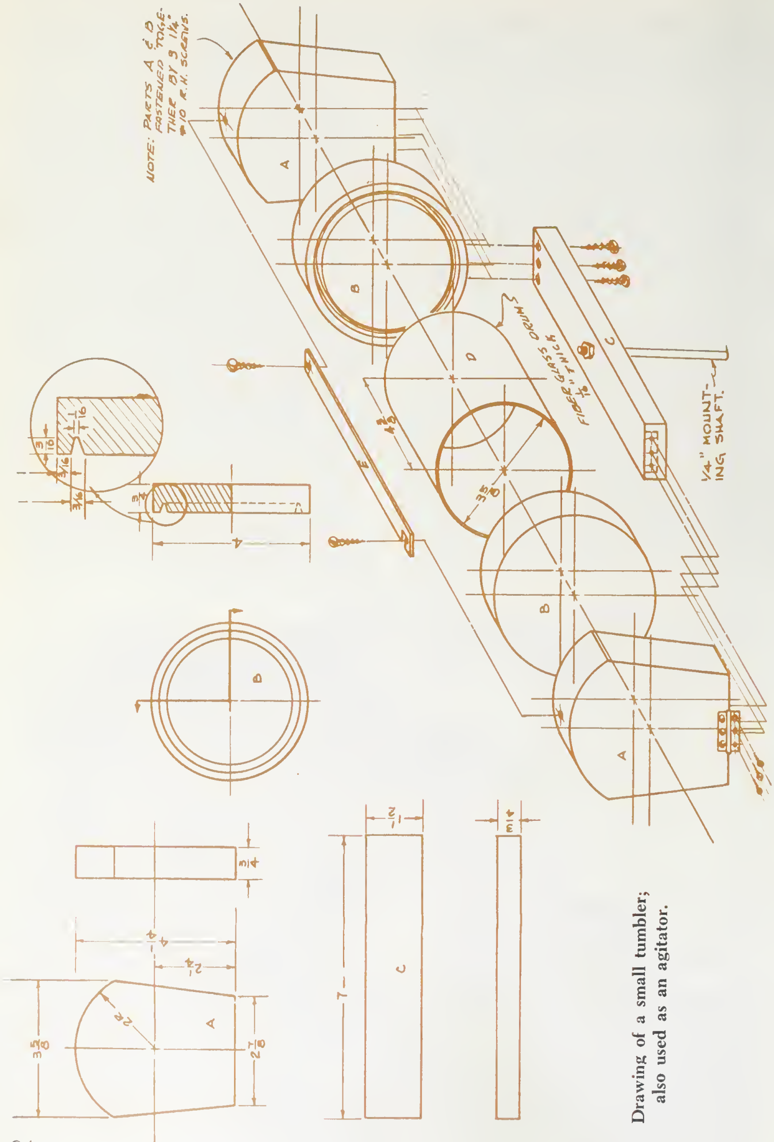
- ***Heat polishing.***

Heat polishing is recommended when a high polish is not needed, such as on the edges of outdoor signs.

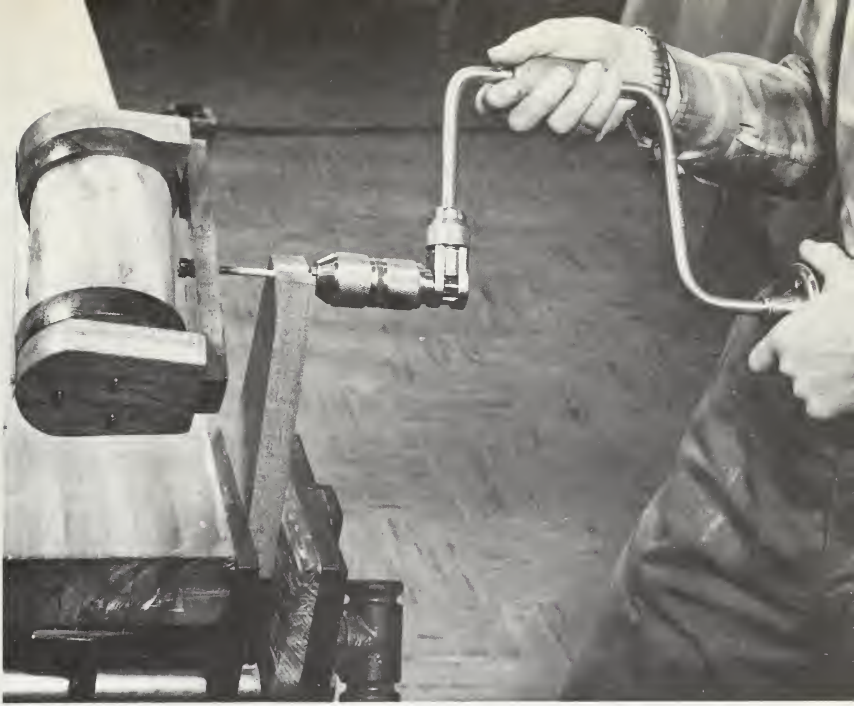
This may be done with an electric welder by simply moving the heated tip down the edge. The speed at which the tip is moved depends on the heat needed, the width of the plastic, and its roughness or smoothness.

- ***Drum polishing.***

A method that industry uses in polishing a large number of small items at once is drum tumbling. This is done by placing the items to be polished, along with small wood pegs, into a drum tumbler. The tumbler turns end over end at 25 rpm for 30 to 45 minutes. This method is popular in polishing buttons. After they are taken out of the drum the buttons are



Drawing of a small tumbler; also used as an agitator.



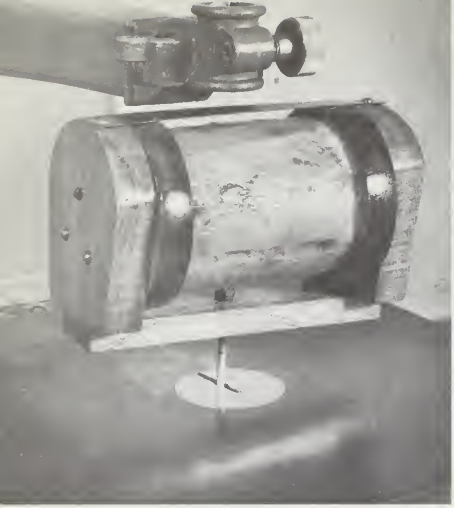
Also, the drum tumbler is used to polish small items and to mix coloring and plastic pellets.

run over a screen, where the wood pegs fall out and at the same time dust is blown out with air.

It is suggested that a drum polisher be made in the school shop to better prepare for industry's methods.

To make a drum-tumbling polisher the following procedure is followed:

1. Secure a plastic or metal pipe, approximately 3 x 8 inches; or make a fiber glass cylinder.
2. Turn out on the lathe two 4 inch wood discs for the ends and cut a groove into the face of each the exact size of the ends of the cylinder.
3. Make two blocks of wood 4 x 5 inches, rounding one end to fit the wood disc.
4. Fasten the blocks of wood to the ends with screws. NOTE: Nails are not used because to refill the tumbler one end is to be taken off.
5. Fasten a cross bar of wood onto the ends.
6. Assemble a faceplate onto the cross bar.
7. Set the lathe to turn 25 to 40 rpm.



A drum tumbler in the jig saw can be used as an agitator on the jig saw to polish small items or to color plastic pellets evenly.

The tumbler was made to be used by hand with the aid of a ratchet brace, or on a lathe that will adjust to turn 25 to 40 rpm. This tumbler is also used as an agitator by assembling on the jig saw. Polishing, or proper color mix, is accomplished by the agitator method as well as by tumbling. The jig saw is set at a slow speed when using the tumbler as an agitator.

Questions on Buffing

1. What is buffing?
2. How is plastic put into the proper condition for buffing?
3. What are the names of the two buffing wheels?
4. Which wheel is to be used first in the process of buffing?
5. Which wheel has the buffing compound and wax put on it?
6. What will happen if the plastic gets too hot on the buffer?
7. What will happen if buffing compound and wax are not kept on the cutting wheel?
8. On what part of the wheel should small pieces be held while buffing?
9. What will happen if the corner of a cube is allowed to get to the wheel first?
10. Why must the plastic be moved around on the wheel while buffing?
11. What causes the plastic to be cloudy while using the cutting wheel?
12. How much time should it take to complete the cutting wheel process on a 3″ x 3″ surface?
13. How much pressure should be applied on the cutting wheel while buffing a 3″ x 3″ surface?
14. Which wheel requires the greater amount of pressure applied while buffing?

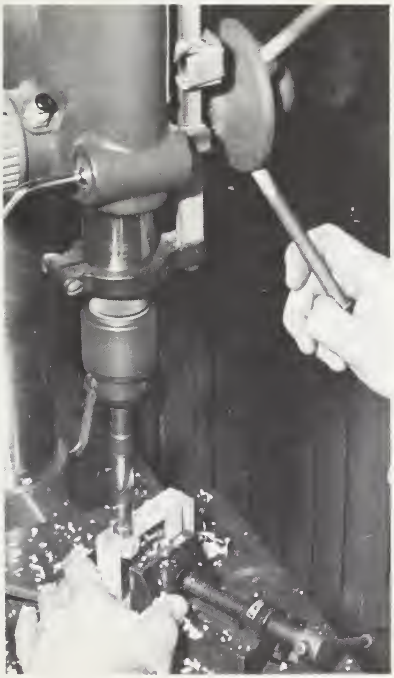
7 USING THE DRILL PRESS

The main purpose of the drill press in the plastic shop is to drill holes. However, there are other uses, which will be discussed in this unit.

It is of major importance that the drills used be ground to the proper angle. Drills ¼″ in diameter and larger should be ground down to have a shorter lip (usually an angle of 26°) to prevent the drill from grabbing as it goes through the plastic.

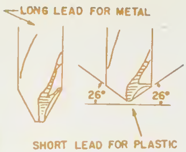
• *Procedure to follow.*

1. First, select the proper drill. The operator can tell the size by reading on the shank of the drills, since they are marked 64°, 32°, 26°, 16°, etc. (In plastic work, the



Use of the drill press.

Another view of the same job.



Proper grinding of the drill.

26° drill angle is commonly used. See drawing.)

2. Next, put the drill in the drill press. This is done by opening the chuck of the drill press by use of the chuck key, putting the drill in, then tightening up with the key.

3. Use a smooth piece of wood on the table, between the plastic and the table, when the holes are to be drilled all the way through the plastic. This is to prevent chipping of the plastic as the drill goes through it.

4. Then the drill press table is adjusted. This is done by placing the plastic on the drill press table, then moving the table up toward the point of the drill until it almost touches the drill point. Then the drill press table is locked.

5. The gage then is set to assure the drilling of the hole the proper depth, or so that the drill will go only through the plastic, as the case may be. This is done by the reading of the gage. For example, if a hole is to be drilled 1″ in depth in a piece of plastic more than 1″ thick, the operator will drill down to the one-inch mark on the gage. A sure method of setting the gage correctly is to move the plastic over to one side and by use of the handle bring the drill down to the wood (if the hole is to go all the way through the plastic). Then set the stop on the drill press. By doing this, the drill will stop when it gets through the plastic. You want the drill to go *completely through* the plastic, but no farther.

6. In drilling a large hole through a small piece of plastic, hold the plastic with a clamp, a small vise, or a pair of pliers. For example, in drilling a ⅝ inch hole in a 1 inch square to make a ring, hold the plastic with pliers, because there is always a chance of the drill grabbing, causing it to take the plastic around as it goes. This would work a hardship on the hand that holds the plastic!

7. After making sure that the proper tool has been selected, hold in the left hand, turn the power on, and use the right hand to bring the drill down by the handle. Often plastic is broken when drilling holes in small pieces by drilling too fast. Drill slowly—that is, by a slow application, releasing the drill to come back up often in order to clear out the shavings. If shavings are allowed to clog the drill, they will cause the plastic to heat and wear an uneven hole. Also the motor may be put to a strain and stalled.

8. If holes are to be made at an angle, they are drilled by angling the table. It is hard to start the drill on a smooth piece of plastic at an angle. This can be made easier by drilling a small pilot hole

while the table is level, in the exact center.

9. If holes are to be 1 inch or more in diameter and 1 inch or more in depth, a coolant should be used. This can be done by first drilling a pilot hole approximately ⅛ inch in diameter. Then fill this hole with heavy oil or wax. The pilot hole is drilled only 95 percent through the material. The wax will help produce a smoother hole as well as keep the drill cool.

The speed should be slow, approximately 2 inches per minute. Attempting to drill the hole too fast will cause the shavings to melt and stick to the drill. The results will be an uneven hole, very hard to polish. The drill is removed often to clean out shavings.

Detail of rat-tail file.

• ***Other tools used in the drill press.***

1. *The rat-tail file.* The file is broken off to about 3 inches in length, with the part that is to go into a handle removed; then the smooth portion is put into the chuck of the drill press. To use the rat-tail file, the drill press is set at 1,725 rpm. This file is used in the smoothing of small inside curves and taking out saw marks and chips. The plastic may be held by hand or the table may be set so that the file will go through the hole. The plastic is kept flat on the table and moved around the file to smooth where smoothing is needed, applying about four pounds pressure. The file may also be used to make holes of other shapes than round. For instance, sometimes a slot may be wanted, or an oval shaped hole, and the file can be used for this purpose. If a drill of the proper size is not available, use a smaller one and file to proper size. This is often done in the making of a ring.

2. *Sanding drum.* A small sanding drum may be used in the drill press in the same manner as the file, for sanding small inside curves. The drill press is set at a slow speed, and light pressure is applied on the drum at all times.

3. *Buffer.* A small buffer may be made by fastening a cloth around a ¼ inch dowel about 3 inches long. About ½ inch of the dowel is left without cloth on it to go into the chuck of the drill press. Two of these buffers are made, one for the cutting wheel and the other for the polisher.

While you are using the buffers in the drill press, the press should be running at a slow speed, and light pressure should be applied at all times.

4. *Countersink.* The countersink is also used in the drill press. *Countersinking* and *reaming* are to be done after the holes are drilled. The amount of reaming to be done is determined by the size of the screw head to be countersunk. Run the drill press at a slow speed while countersinking to obtain a smooth cut. The sure method of doing proper countersinking is to test on a piece of scrap plastic.

5. *Frosting.* Frosting is the process of dulling a high finish. Frosting a rod of plastic can be done in the drill press by putting one end in the chuck and holding 00 sandpaper against the plastic with very light pressure. The plastic turning at 1,725 rpm is given a frosted effect. By reversing the ends, all parts of the rod may be frosted. This method is generally used for frosting for cat-tails of a centerpiece.

WARNING: A rod longer than 8 inches should not be treated in this manner.

Questions on Filing

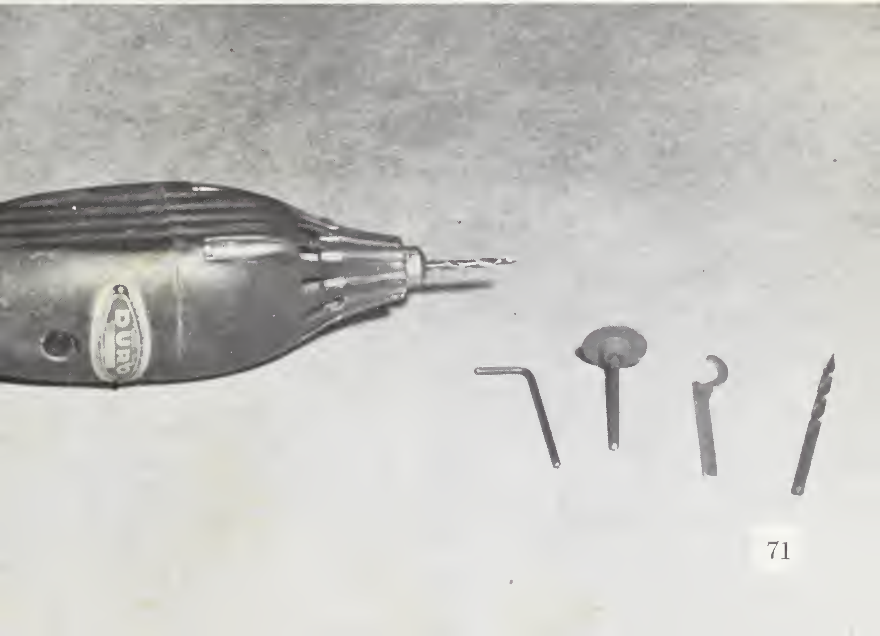
1. Where is the size of the twist drill marked?
2. What part of the drill press is the twist drill put into for use?
3. Why is it a good practice to use a smooth piece of wood between the drill press table and the plastic?
4. Why should the gage be set on the drill press?
5. What tools are used to hold plastic while drilling?
6. Why should the plastic not be held with the hand?
7. Why release the drill while drilling a hole in plastic?
8. What will cause plastic to break while drilling large holes?
9. How are holes drilled at a 30 degree angle?
10. What tools are used in the drill press?
11. What use does the rat-tail file have in the drill press?
12. What use does the sanding drum have in the drill press?
13. How is the buffer made that is to be used in the drill press?
14. How may one be sure to countersink to correct amount?

8 USES OF CARVING TOOLS

Several different tools are used for carving plastic. They all have the same principle as a portable drill or a flexible shaft. Some of the trade names of shop carving tools are: the Duro Heavyduty Grinder, the Handee tool, and Rotary Electric. The flexible shaft is simply fastened onto a 1,725 rpm electric motor, but the best carving tool is a portable drill operated at 4,000-5,000 rpm. This speed has been found to do the best carving, at the same time allowing the operator complete control of the tool.

The *twist drill* that goes in the carving tool may be bought, or made in the shop. The best practice is to learn to make carving drill points on high-speed twist drills, because in learning to carve plastic you may often break drill points, and should be able to

Carving tool, with accessories. See page 72.



make a drill or sharpen a broken drill. (Grinding takes away the cutting edge near the point, also.)

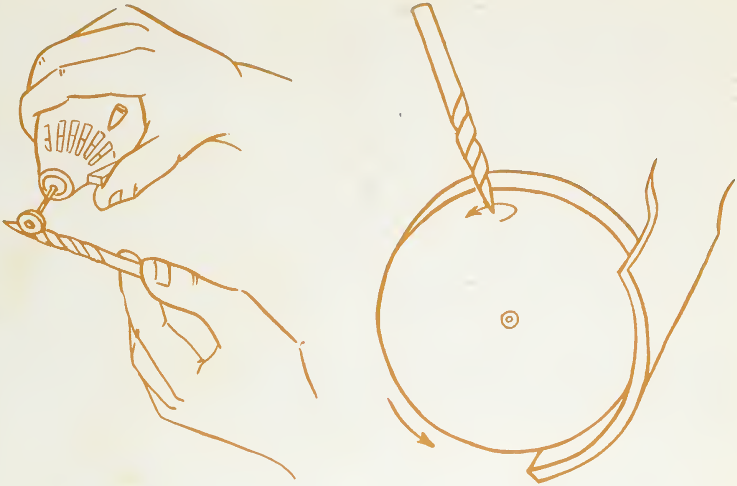
To make the carving drill, select a twist drill the correct size, which is determined by the type of carving to be done and by the sizes of drills to be used. For fine, tedious carving, in very small pieces of material, such as ear screws, 1/16 to 3/32 inch drills are best.

WARNING: Some of the carving tools are not equipped with chucks that will take a drill as small as 1/16 inch. For carving large flowers, in book ends or any other larger pieces, 1/8 or 5/32 inch drills are used.

In grinding down the twist drill to make the carving drill, the slow grinder is the best to use, because by using the slow grinder, one is not so likely to get the twist drill hot. Overheating the drill is to be avoided because it will take the temper out.

The grinding of the twist drill to a fine point is done at a 60 to 75 degree angle. This can best be done by holding the twist drill on the grinder at the required angle and turning it around until it is ground down to a fine point, keeping the point in the center of the drill. (If the point is not kept in the center, the drill will vibrate while carving, causing a larger cut.) When grinding down a drill for carving, keep a container of water close by into which you can dip the heated drill from time to time to keep it from getting too hot. See pictures showing filing and sharpening.

The grinding of the twist drill takes away the cutting edge of the portion ground down. In order to get a new cutting edge on the lip of the drill, a small emery is used. This is in the shape of a disc, about 1 inch in diameter, 3/16 inch



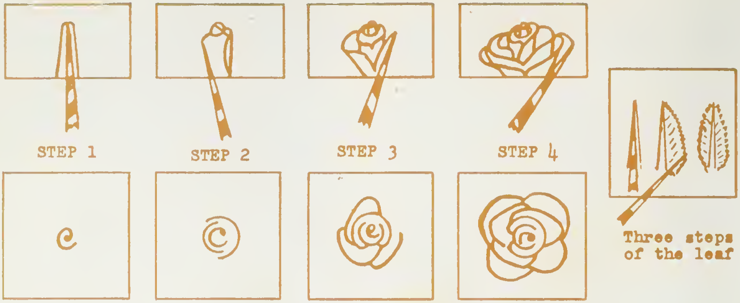
Making a carving drill from a twist drill.

thick in the center, and tapering to an edge about 1/32 inch in thickness. This emery is fastened onto a spindle which will enable it to be used in the same tool used for carving. With practice, you will be able to grind a cutting edge back onto a twist drill after using it for carving. In doing this, hold the grinder in one hand and the twist drill in the other; or put one of them in a vise and move the other with the hand. Now you are ready to grind out the flute. This done, grind the lip clearance back onto the end of the drill which puts a cutting edge back on the drill.

When carving drill gets dull, it can be sharpened by touching up the flute and the lip clearance with the emery again.

Questions on Carving Tools

1. Why is it a good practice to make carving drills?
2. What will determine the size of twist drill from which the carving drill is made?
3. While grinding the twist drill down, why should it never be overheated?
4. How can overheating be prevented while grinding down?
5. To what angle should the twist drill be ground?
6. What will happen if the point is not kept in the center?
7. What is used to get the cutting edge on the lip after grinding down to a point?
8. At what speed should a carving tool run?
9. What are some of the tools that may be used for carving?



CHICAGO WHEEL AND MFG. CO.

Rose. It takes time to master the rose. Use plastic at least ½ inch thick. Practice the petal pattern on scrap stock. Then, to start a flower, make a small center as in the side view and gradually increase both radius and depth as you go along. Nine or ten leaves are ample, but keep the flower well balanced.

- *Carving plastic.*

Interior carving is one of the most popular treatments of clear plastic. Flower designs, carved in and filled with color, add to the beauty of cut, polished plastic shapes.

To learn to carve you must do two things: (1) Learn the correct procedure. (2) *Practice* carving, for, as in typing, or driving a car, practice is a "must."

To consider procedure now: The correct procedure in carving a rose, for example, is as follows (the rose is suggested because it is a simple design for a beginner):

1. Use the correct carving tool—a rotary, hand electric tool with a high-speed twist drill ground down to a fine point, with the flute clearance ground back in.

2. Use a well-polished piece of plastic so that you can see what you are doing from all surfaces. (Plexiglas lends itself well to interior carving.)

3. Start the drill where the center of the rose is to be, going up into the plastic. The most comfortable way to do this for the right-handed student is to hold the drill in the right hand and the plastic in the left, moving both as necessary. Have the light falling on the work so that the reflection will not interfere with carving. The drill is moved slowly as the first hole is made, moving the drill up and down or slightly withdrawing it to keep from heating the plastic. The first hole should be drilled at a slight angle and approximately the height of the desired design. After the first hole is made, the drill is then moved around to make the first small central petal.

4. The second petal is started by first bringing the drill out and

starting it back about halfway up in the first petal, moving it around in such a way as to get the desired shape as the proper height is made. This second petal has a large, fanlike sweep, but is not quite as high as the first. Do not attempt to carve the entire petal at one sweep, but carve only about ¼ inch at a time so as to have better control of the shape and also not to strain the drill. Drills are often broken when this procedure is not followed.

5. The remainder of the petals are started in the same way, each being started down just under the last one carved. The drill can be moved around easily after the first petal is carved, to make the desired shape. Look down through the top as well as from all sides to see that the proper shape and proportions are being formed. If the operator looks through the top only, some of the petals might be much higher than they should be, because it is hard to determine height looking down from the top. Using side view only, it is hard to get proper spacing and shape.

6. After carving each petal, clean out the shavings by slightly withdrawing the drill and then making another sweep, which might be called the "clean" sweep. The unpracticed carver will have a rough edge on his petals. But he should not be discouraged, for by practice he can learn to smooth the edge by running the drill carefully back over the petal.

7. If a darker shade of color is desired, the shavings may be left

Interior carving.

Carved candle holders.

Applying dye in a carved rose.

in to absorb more dye. But if a lighter shade is preferred, all or part of the shavings may be removed. The shavings absorb additional dye, darkening the color.

8. After the carving is finished, the rose is ready to be colored. (See "Dyes and Coloring," page 78.) This is done by filling the carved rose with the proper colored dye by means of a medicine dropper. There should be a medicine dropper for each color of dye, and you must be careful never to use the wrong one. Mix the dye so as to give a standard shade by filling the carved part with dye. Leave dye in. When the dye is applied, it should be allowed to set 5 to 10 minutes before putting in the plaster of paris.

When the plaster of paris is put into the rose, it is mixed well by stirring with a small plastic paddle of the proper color: that is, a red paddle if the dye being used is red, or a yellow paddle if yellow dye is being used. Care should be taken to use the right paddle, red for red dye, yellow for yellow, etc. If enough care is taken, beautiful colors can be obtained in plastic dyeing.

When the coloring is finished, the rose is filled with plaster of paris or molding powder up level with the surface of the plastic, and allowed to dry. The dye in the rose is just enough to sufficiently wet the filler. If too much filler is applied, it will not set and therefore will fall out. The filler will

fall out if so much is applied that it will not be thoroughly wet. Sometimes in an effort to hasten the drying of the filler, too much is applied. The filler should just fill the cavity.

If by any chance too much plaster of paris has been used, it should not be put back into the plaster of paris container, because it will be somewhat colored with the dye used and so will damage future projects of other colors. In other words, the material in the plaster of paris container, because be kept clean. If a white color is desired, the rose will simply be filled with plaster of paris mixed with water instead of dye.

Leaves are discussed below. As for pansies and orchids: the center (or pistil) of a *pansy* is drilled and colored by applying dye with medicine dropper or brush. After the dyed portion dries, the petals are cut and dyed with a brush. The paste (or filler), made by mixing with water, is then applied to the entire flower. The *orchid* is painted with brushes, so as to get the varying shades of color, and filled as the pansy.

9. *Carving of leaves:* (1) Drill a hole at an angle of about 25 degrees to the desired length. (2) Remove the drill to clean out the shavings. (3) Reinsert the drill fully. (4) Bring the drill down in a curving sweep to make one side of the leaf. (5) Reinsert the drill and do likewise for the other side. The leaf is now complete.

In carving any flower which may have different colors in the same flower, the coloring may be done as the parts are carved. Thus the center of a pansy can be carved and colored before the petals are carved. Also, in the carving of an orchid, the desired shades may be put in by use of a small brush. This, however, is a very tedious job, which should be done with great care.

Questions on Carving

1. What conditions should the plastic be in before carving?
2. Why should the drill be slightly withdrawn often while drilling the first part of a rose?
3. Where should the second petal be started?
4. Which of the petals should be the highest?
5. How much of a petal should be carved at one sweep?
6. What is being done wrong when the drill breaks?
7. How may one be sure the proper shape and proportions are being formed?
8. When and how are the shavings cleaned out of the petals?
9. When may the shavings be left in the petals?
10. How should the dye be put in the carved rose?
11. What will happen if the wrong medicine dropper is used?
12. Why should the leaves be carved after filling the rose?
13. What is wrong with the carving when the bottoms of the leaves are too large?
14. How may the different shades be put in an orchid?

9 DYES AND COLORING

Plastic dyes are used with many projects besides interior carving. They are purchased in powder, liquid, or paste form. They may be purchased in a rainbow of colors or in the three primary colors: red, yellow, and blue.

It is recommended that a rainbow of colors in both paste and powder be purchased with larger amounts in the primary colors. This will provide the desired color when needed, as well as materials for learning the proper method of mixing dyes. There should be the necessary supplies in the experiment station, which will be discussed in a later chapter, to learn the proper method of securing the needed colors and shades.

After the dyes are secured or mixed there are different methods to use them, depending on the type as well as the amount to be dyed.

Equipment for dyeing.

- ***Dry coloring.***

Industry's method for dry coloring large amounts of plastic powder or pellets is called *drum tumbling*. The procedure is as follows:

1. Place 100 to 150 pounds of plastic powder or pellets into a 175 to 220 pound drum. This is an end-over-end tumbler, rotating at an angle.

2. Place the accurate amount of paste in the drum, to determine the hue as well as the shade desired.

3. Tumble at 25 to 40 rpm for 15 to 30 minutes, depending on the color. Higher speed will result in uneven coloring. Slower speed will permit the powder to slide with the walls of the tumbler, which also results in uneven coloring.

A small drum tumbler (illustrated on page 66) may be made in the shop. The procedure in using it is the same as for the larger drum tumbler. It is suggested that the pupils make and use a drum tumbler so as to prepare them better for industry's methods of coloring.

Follow the same procedure to make a tumbler for coloring as for polishing. NOTE: It is important

to clean the drum thoroughly when changing from one color to another. This is done by vacuuming and wiping with a cloth saturated with butyl acetate.

- ***Wet coloring.***

To mix wet coloring dyes, one tablespoonful of powdered dye is added.

- ***Mixing.***

One tablespoonful of the powdered dye is added to three quarts of acetone. This mixture is shaken and one quart of warm water added. However, smaller amounts should be mixed, in these proportions, because the mixed dye loses its strength with age.

To make a *leaf-color green dye*, blue and yellow liquid dyes are used. If the dyes are of the same strength, 60 percent yellow and 40 percent blue will give a good leaf color. However, if a darker or lighter shade of green is wanted, the proportions can be varied to obtain it.

To make a *violet dye*, use about 75 percent blue and 25 percent red. Adjust these proportions for various shades. This color is used to paint carved orchids.

Orange is made by mixing red and yellow in 50–50 proportions.

Pink is made by simply making a very weak red dye, which is done by adding acetone and water to red dye, in the proper proportions.

- ***Using dyes.***

A separate medicine dropper is used for each color. Always shake the dye before using because even well-dissolved dye has a tendency to settle to the bottom of the container.

By use of the proper medicine dropper, fill the carved portion which is to be colored with the dye. Then put the top back on the dye bottle airtight. This is done because acetone evaporates easily.

If the carved portion is small, and will not hold much dye, allow the dye to dry before putting in the plaster of paris. But if the carved portion is large, such as a flower, the proper procedure is to put the dye into the flower and then put the plaster of paris in on top of the dye.

Various shades may be obtained by using different mixtures and by varying the drying time. To obtain a lighter shade, the plaster of paris is applied immediately after the dye. For darker shades, the dye is allowed more time to dry before applying the filler.

Often outer surfaces are to be colored, such as a cattail centerpiece. Place the dye in a large enough container so as to cover the piece completely when immersed. Place the material to be dyed in the container and allow it to stay until the desired shade is obtained. (The desired shade can be obtained by testing with small test pieces exposed for varying lengths of time.) In actual practice, merely dip to get a light tint; leave in the dye thirty minutes for a light shade; leave in an hour for the darkest shade possible. Be-

tween-shades are obtained by exposing to the dye forty to fifty minutes.

Questions on Dyes and Coloring

1. What is the correct rpm for a drum tumbler?
2. What will happen if the drum tumbler turns too slowly?
3. Why is it recommended that a small drum tumbler be made in the school shop?
4. What are the three primary colors?
5. What proportion of the liquid dye is water?
6. What colors are used to make green?
7. How much dye powder should be used to make one gallon of dye?
8. If the dye is too dark in color, how can it be made lighter?
9. How is the dye put in the carved design?
10. Why should there be a medicine dropper for each color of dye?
11. Why should the top be kept on the dye while not in use?
12. How may various shades be obtained?
13. How is the coloring done when outer surfaces are to be colored?

10 MOLDS AND JIGS

It is interesting to work out molds and jigs to form heated plastic into desired shapes. However, most of us will have a tendency to make projects for which someone else has already worked out a mold or jig, if not encouraged to give some thought and work to making our own. We should design and make for ourselves a mold or jig, or at least change the design on one already made. After this work has been done, we are better able to work out a jig or mold that might be needed for a different project we might want to make later.

Jigs and molds commonly used are for bowls, trays, smoking stands, round bottoms for boxes, letters, towel racks, legs for coffee tables, candle holders, etc.

• *Molds for bowls.*

Plastic bowls are popular projects; and therefore molds of various sizes for making them are needed. For example, if a 10 inch disc of plastic, ⅛ inch in thickness, is to be used, a piece of wood 2 x 10 x 10 inches is required. (Plastic discs are cut out with the jig saw.) This is made round by first cutting on the band saw and then putting it on the lathe by use of the faceplate. It is then turned smooth on the circumference. Then the center is cut out; this will be 7 inches in diameter and 1½ inches deep. This piece is sanded smooth on the inside. Then a wood disc 6½ inches in diameter and 1 inch thick is turned out and sanded smooth. The circumference of this disc is also sanded smooth to prevent a rim around the plastic bowl.

For this mold, use a disc of plastic 10 inches in diameter and ⅛ inch in thickness, which will produce a bowl with a 7 inch base, 1½ inches in depth. Heat the disc and place on the larger portion

Molds for Making Different Sized Bowls, Using 10″ Disc of Plastic

Center of Mold	*Bowl Bottom*	*Bowl Depth*
9″	9″	½″
8½″	8½″	¾″
8″	8″	1″
7½″	7½″	1¼″
7″	7″	1½″
6½″	6½″	1¾″
6″	6″	2″
5½″	5½″	2¼″
5″	5″	2½″
4½″	4½″	2¾″
4″	4″	3″

Outside part of mold is 10″, the same size as the plastic disc used. The size of the cut-out portion of the mold will depend upon the depth of the bowl. See top of page 82.

Molding candy tray.

of the mold. To be sure that it is centered on the mold, the outer edge of the plastic should be flush with the outer edge of the mold.

WARNING: To avoid burning the hands, always use gloves or hot pads when handling hot plastic. Never use pliers or other iron tools for this purpose, because they cool the portion touched, causing the plastic to form unevenly.

Now that the heated plastic is properly placed on the larger portion of the mold, the smaller portion of the mold is placed on top of the hot plastic in the center of the mold and pushed down slowly. As it is pushed down with one hand, use the other hand to even the parts that do not form easily. This process should be done fast, since plastic ⅛ inch in thickness will cool in about one minute and become too hard to mold. Care should be practiced to do a good molding job on the first try, for reheating and remolding lead to inferior products.

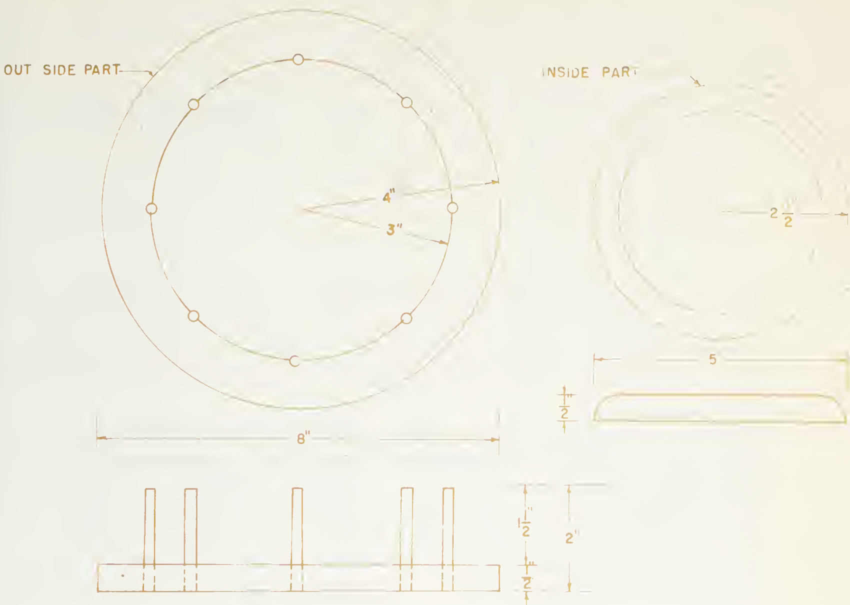
If the plastic forms in such a way that the center piece cannot come out after the plastic is cold, it should be removed while the plastic is still slightly flexible. The plastic will be completely cool in about two minutes, and may then be removed from the larger part of the mold. This mold may be used to mold either squares or discs.

- ***Round-bottom bowl.***

Another type of mold, for a round-bottom bowl, is made by drawing a circle the desired size on a smooth piece of wood one inch or more in thickness. This circle is then divided into eight equal parts. Holes ⅜ inch in diameter are drilled almost through the wood at each division line around the circle. Then ⅜ inch dowels 3 inches long are put into the holes. The tops of the dowels are rounded and smoothed so that they won't scar the hot plastic when it is put on them. The center part of the mold is made by cutting a round piece of wood ½ inch smaller in diameter than the circle, and smoothing it. This mold is used in the same way as the one described above.

- ***Tray molds.***

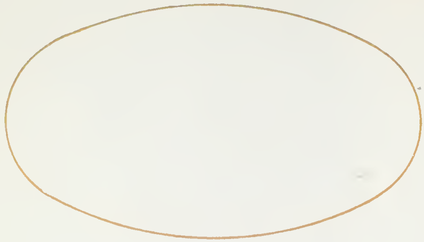
Molds for trays are made by drawing the desired size of bottom on smooth pieces of 1 inch wood. Measurements are then made 2 inches from each corner for ⅜ inch holes. When the holes are drilled, ⅜ inch dowels, 3 inches



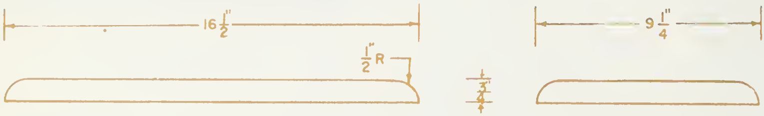
Mold for an 8 inch bowl.

long, are placed in them. Then a piece of wood ½ inch smaller in width and length is cut and covered with felt. All parts of the wood that will come in contact with the hot plastic should be smoothed and without sharp edges. For example, suppose you wish to make a tray 12 x 15 and 1 inch deep. This can be described without illustration. Mark off on a smooth piece of wood at least 14 x 17 inches, a 12 x 15 inch parallelogram. Then drill ⅜ inch holes 2 inches from each corner. In these holes now place ⅜ inch dowels, 3 inches in length, with smoothed and rounded heads. Then cut a piece of plywood 11½ x 14½ inches and smooth it. This plywood piece is to be covered

The molding of a bowl from a 7 inch square.

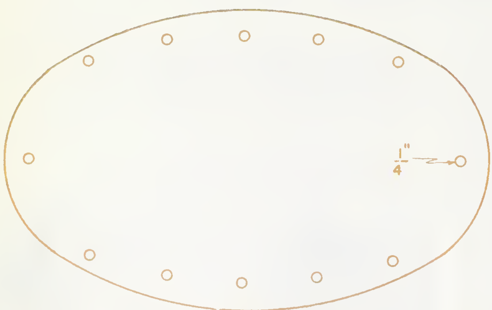


Inside part of tray mold.

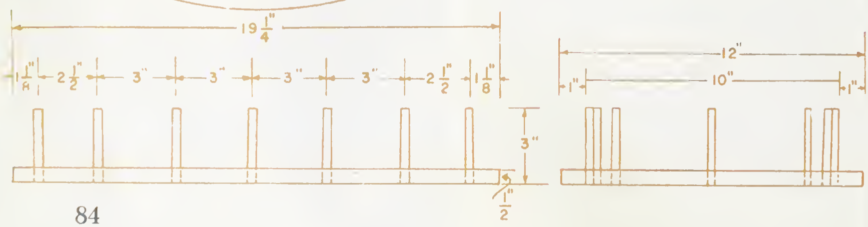


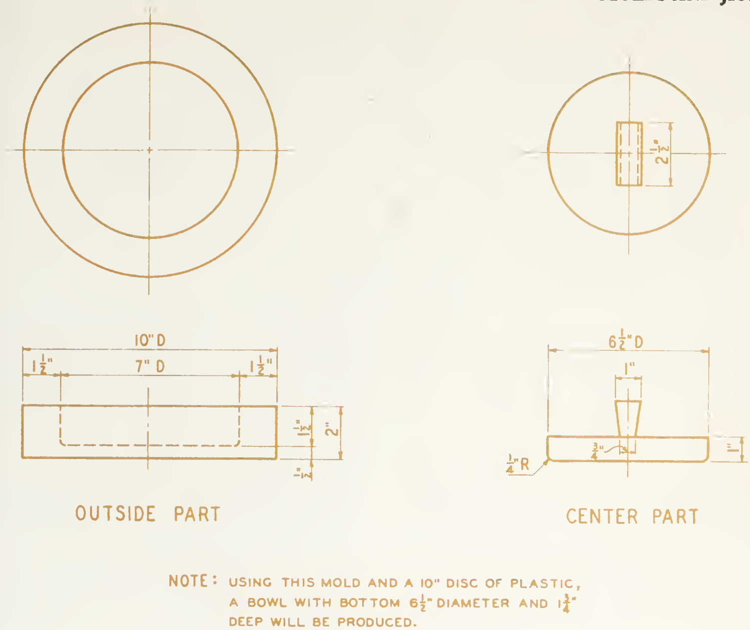
with felt or smooth cloth. (The reason for using felt or cloth for this mold and not for smaller ones is that smaller ones can be sanded to smoothness, whereas it is easier to line the larger mold. Then cut the plastic 14 x 17 inches.

The plastic is ready to be finished by the proper methods of machine sanding, scraping, hand sanding, and buffing. Then it is ready to heat; and when the plastic is hot, it is placed evenly on the part of the mold that has the



Outside part of tray mold.





Bowl mold.

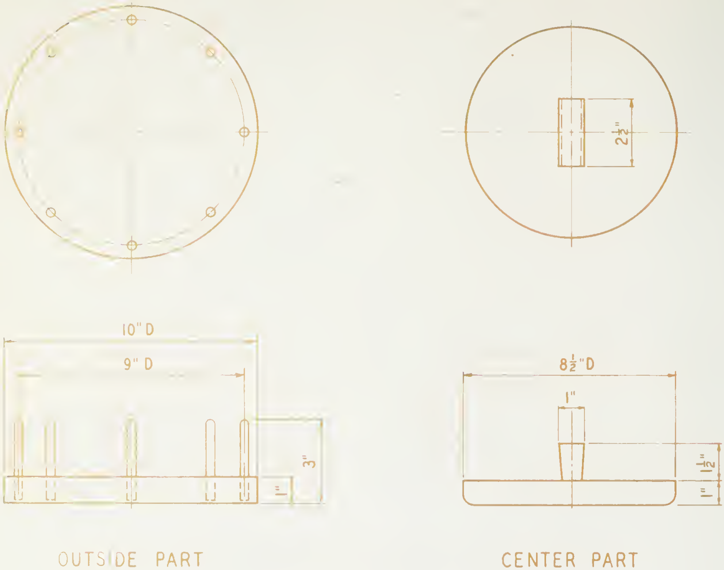
dowels in it. Then the small part of the mold, with the felt on it, is placed on the plastic and pushed down.

Often the corners won't be just right, but they can be moved around and put into proper shape while the plastic is hot. Check to see that the sides and ends are of even height before the plastic gets cool.

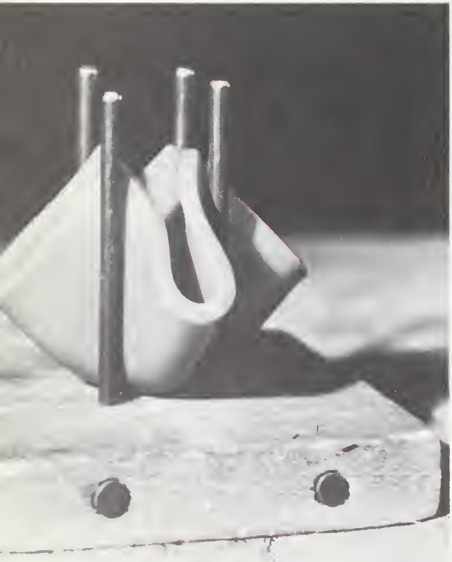
Molds for candle holders are made by using a smooth piece of wood 1 x 4 x 4 inches. Diagonal lines are drawn from corner to corner to get the center. At places 1¼ inches from the center on each line are bored 3/32 inch holes. In order that the mold will sit level, these holes are countersunk in the bottom to receive the head of a twenty-penny nail. The nails, with rounded points, are driven into the mold from the bottom.

Then a ⅜ inch dowel, 6 inches long, is rounded off to use in putting the plastic in the mold. The way to use the mold is to place a piece of hot plastic ⅛ x 3½ x 3½ inches on the mold, so that each corner is at the nails, for one design.

For another design, the corners may be placed evenly between the



Another type of bowl mold.

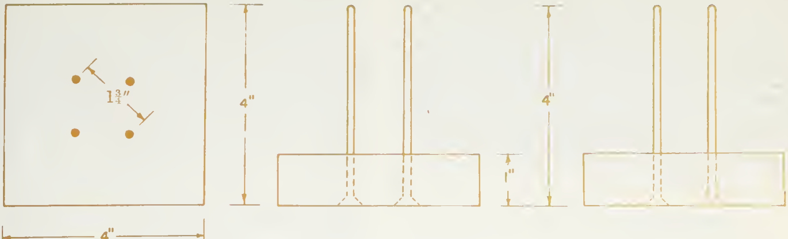


nails. Using the dowel, the hot plastic is now pushed down with one hand. The other hand is used to get all corners evenly placed.

- ***Round-bottom box mold.***

A mold for a round-bottom box may be made by turning out a wood cylinder the size of the inside of the desired box. For example, a wood cylinder 3 inches in diameter and 5 inches long makes a nice size for a cigarette box, or one 2 inches in diameter

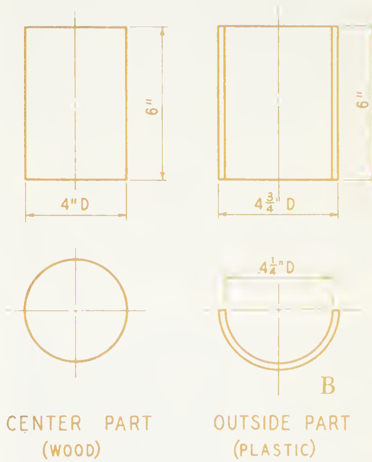
Use of a mold in making a candle holder.

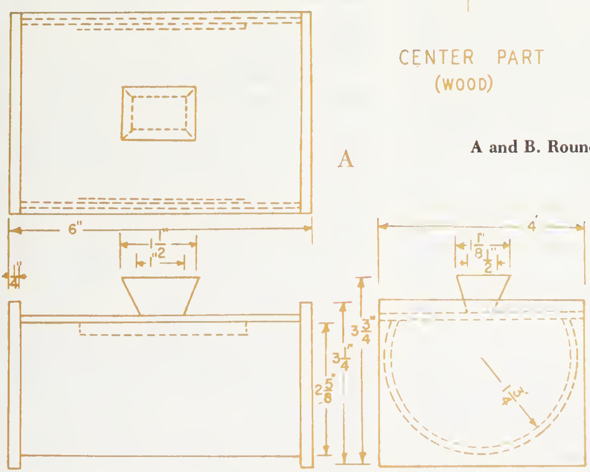


Candle holder mold.

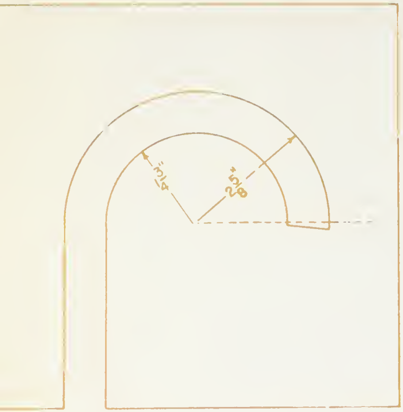
and 3½ inches long is good for a trinket box. After turning to the correct size, this cylinder should be sanded smooth, except on the ends, which need not be sanded.

For making various sized boxes, wood cylinders can be turned, ranging from 2 to 4 inches in diameter and increasing in size ¼″ at a time. That is, 2″, 2¼″, 2½″, etc. The way to mold the rounded portion of a box is as follows: Take a piece of plastic of the



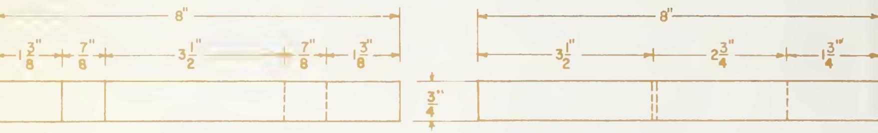


A and B. Round-bottom box.



- *Making a jig.*

The making of a jig is usually thought of in the preparation for forming a project, or a portion of a project, that is different from the general run of projects made in the plastic shop. For example, to make a coffee table with legs of special design, that is, not straight line design, draw the legs on wood full scale. Then saw that out on a band saw or jig saw. The sawed edges should be smoothed by filing and sanding. These two portions are then spread apart the



Jig to form walking stick handle.

proper size (say for a box 2″ in diameter). Heat the plastic, and place around the 2 inch cylinder. Then place over the heated plastic a cool piece just a size larger, that is 2¼ inches. Let this cool and then remove from the wood cylinder.

For any size box, a piece already molded just ¼ inch larger can be placed over it to hold it in shape while it cools. What we have just said is true if material ⅛ inch in thickness is used, which is the most common thickness for this project.

This same type of mold may also be used in making a part of the upright piece used in trophies. A walking stick handle is formed with a wooden mold.

proper distance so as to receive the hot plastic. The plastic is fitted between the two sawed forms and fastened there to cool.

The design may be such that it won't allow the pieces to be separated and all parts be in proper shape. If so, the jig may be made by drawing the design full scale and then placing nails or dowels around the lines where the turns are made. When the plastic is hot, it is woven in between the nails and allowed to cool.

If nails are used, the heads should be ground off and smooth. They should also be strong enough not to give.

Once you have worked out a design for yourself, the chances

Using a jig to form handle of walking stick.

Use of a jig in making a toothbrush rack.

are you will be able to make a jig to produce it. The variety of jigs and molds that can be made is extensive.

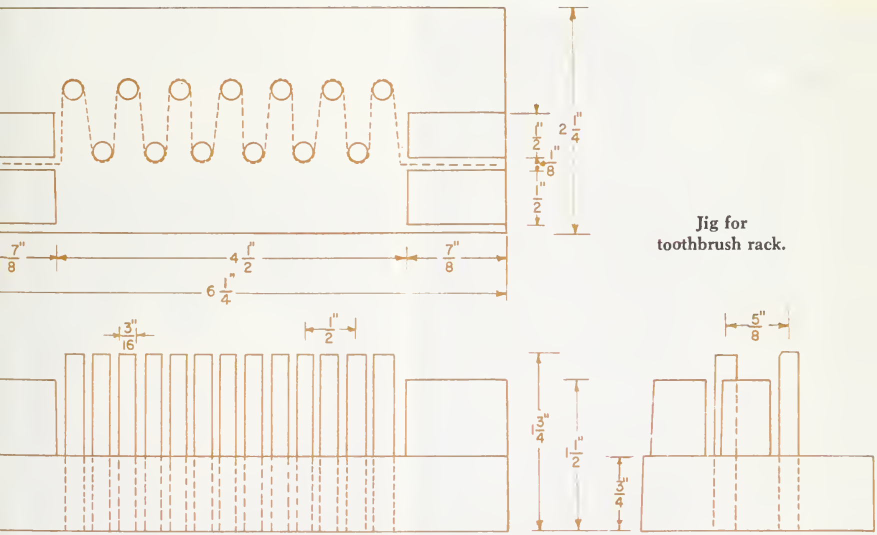
• ***Heating plastic to be formed.***

Acrylic plastic is the best material to use because it can be heated and made flexible, making it possible to shape it into various forms by the use of molds and jigs.

Plexiglas and Lucite are acrylic plastics. It is hard to distinguish between these and other plastics by sight, unless the masking paper bearing the trade name is still on. So be sure of your material.

• ***Ways of heating.***

Ovens and their uses. The electric range is the most practical heating equipment in the shop, although less costly equipment (hot



Jig for toothbrush rack.

plates) or more costly (bulb-heated units) can be used.

Procedure to be followed in preparation for heating:

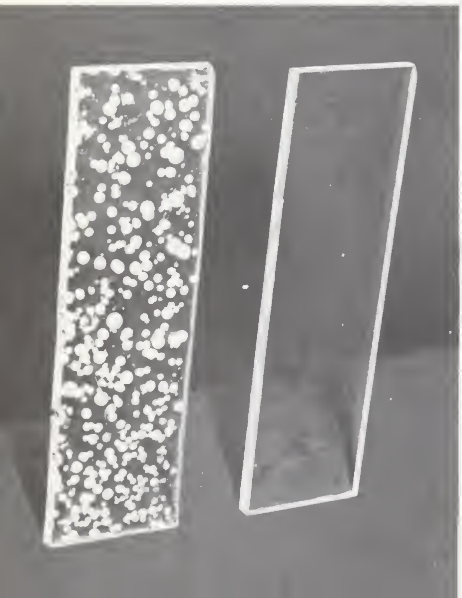
1. Equip oven with rack for larger pieces and metal tray for smaller pieces. This keeps the material from falling down onto the cover of the heating unit, causing blisters.

2. Heat oven to 250–300 degrees F.

3. Check to see that the piece to be heated will go in the oven. When very long pieces are to be heated (such as uprights to smoking stands), heat the center over an outer heating unit and bend so as to put in the oven.

4. To avoid sticking together, never place one piece upon another in the oven.

Blisters, showing result of overheating.



Preparation for handling hot plastic when it is ready to be removed from the oven:

1. Have the mold or jig ready for use.

2. Have two hot pads or a pair of cloth gloves ready for use.

WARNING: Pliers or other metal tools are not to be used for handling hot plastic because the metal cools the part it touches, causing it to form unevenly.

3. Have molds and work table free from dust and grit. Plastic is easily scarred while it is being formed.

4. Be sure to work fast while forming thin material (1/16 to 1/8 inch) because it cools very rapidly. (See Table 3.)

Table 3

TIME FOR FORMING HOT PLASTIC BEFORE IT COOLS

Thickness (inches)	*Time (seconds)*
1/16	75
1/8	90
3/16	105
1/4	115
1/2	120
3/4	125
1	130
2	140
3	150

- ***Molding hot plastic.***

The plastic is taken out of the oven as soon as it is uniformly flexible (see Table 4) and placed in the mold or jig prepared for forming it. If it does not form as

In molding a disc to form a bowl, first remove the masking paper from the plastic.

Remove the hot plastic from the oven. Be sure to use gloves.

desired, it may be reheated and formed again. However, plastic gets harder to form the more often it is heated, and should not be reheated more than three times. Study the mold or jig to see how it works before using it so as to avoid reheating if possible.

Keep the material in the mold until it is cool. However, some molds may be made in such a way that the center piece will not come

Place the disc in the mold to form a bowl.

When cool, remove the bowl from the mold.

Table 4

HEATING TIME REQUIRED AT 300°F. FOR PLEXIGLASS AND LUCITE

Thickness (inches)	*Clear and Transparent (minutes)*	*Opaque (minutes)*
1/16	12	20
1/8	20	30
1/4	26	35
1/2	28	38
3/4	30	
1	32	
1 1/4	34	
1 1/2	36	
1 3/4	38	
2	40	
2 1/4	42	
2 1/2	45	

NOTE: The author has never worked opaque material thicker than 1/2 inch.

out after the plastic is completely cool. In such cases remove the material while it is still somewhat flexible. This can be done without damaging shape.

Other heating. Spot heating is best done on the outer heating unit of an electric range. This type of heating is needed when only a portion of a piece of material is to be heated, such as a long piece used for making a towel rack. The ends are heated, one at a time, and placed in the jig to cool. If a twist in the center is desired, the piece is held over the heating unit and twisted when it gets hot enough to bend easily.

The heat regulator set on "medium" is most effective. The plastic must be turned so as to heat evenly on all surfaces, holding it about one inch above the heating unit. Check the heated portion often, using hot pads or gloves, to see when it is flexible. Plastic is considered sufficiently flexible when all the heated portion will bend evenly and easily.

During the process of checking, if one portion is more flexible than another, that portion needing more heat is held close to the heat while holding the other away.

WARNING: Do not attempt to force the material to bend. If force seems necessary to get it to bend, it is not hot enough and will break. If the heated portion is not taken away from the heat soon after it becomes flexible, it will get too hot and blisters will appear in it. Blistered plastic is ruined, for the blisters will not come out.

Questions on Molds and Jigs

1. What size mold is to be used for a 10 inch plastic disc to be formed into a bowl?
2. Why should the parts of the mold that are to come in contact with the plastic be sanded smooth?
3. How is the heated plastic properly placed on the mold?
4. What is the required size of the plastic to make a tray 12 x 15 and 1 inches deep?
5. How far from the center are the holes drilled in a candle holder mold?
6. What is the size of the plastic to be used in the candle holder mold?
7. What are the two positions in which the plastic may be placed in the candle holder mold?
8. How may a jig for forming the legs of a coffee table be made?

11 GLUING AND CEMENTING

A good glue joint has strength, is not visible to the eye, and has glue only on the surfaces to be joined. Care must be taken to time accurately the soaking of the plastic in the glue; to keep excess glue off surfaces not to be glued; and to be sure the surfaces are level before gluing.

All needed equipment must be at hand before starting the gluing process. The gluing table must be clean; even a few particles of grit in the glue or on the gluing surface will cause a poor joint.

- ***Materials needed.***

1. A glue table with metal or marble top.
2. Catalyst.
3. Vises.
4. Smooth blocks—such as Formica on plywood.
5. Spring jigs.
6. Spring clamps.
7. Double bar clamp.
8. Ethylene dichloride—used in gluing plastic to plastic.
9. 60 percent methylene chloride and 40 percent methyl methacrylate.
10. Vinyl trichloride.
11. Glue trays with woven wire in the bottom. The wire is to prevent grit from getting on the plastic and causing glue bubbles.
12. Epoxy-cement, or an all purpose glue, used for gluing plastic to non-plastic.
13. Masking tape.

- ***Types of glue joints.***

1. Two clear pieces.
2. Clear on top of colored.
3. Gluing a handle in a gavel.
4. A patching glue joint.
5. Gluing plastic to metal, masonry, or wood.
6. Gluing hot plastic to cold plastic.
7. Gluing without the use of clamps.
8. Gluing brackets for signs, and mounting signs.
9. Colored glue.

Gluing plastic is accomplished by many different procedures, depending on the type of joint needed. Some of the common types of glue joints are:

1. *Gluing a polished surface to a polished surface.* If the project will permit, it is best to do the gluing before machine sanding. To glue, soak both surfaces in ethylene dichloride for 5 minutes, then drain the excess. Clamp with spring clamps. Take care not to

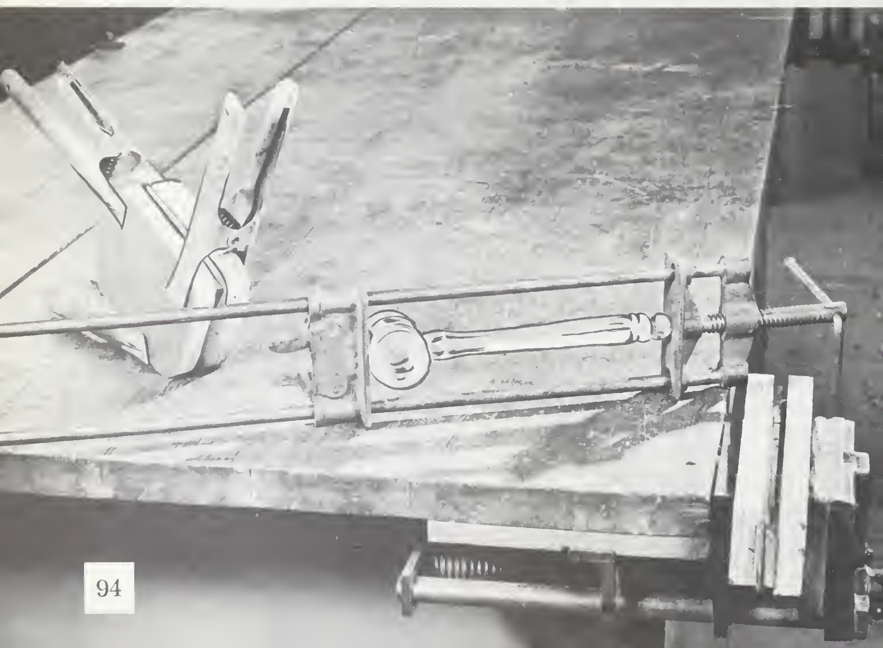
get glue on the top and bottom surfaces. Crazing is often caused by glue on the surfaces. Spring clamps are used in this type of joint so that the pressure will remain the same until the glue has set. The clamps are left on for approximately 4 hours.

2. *Gluing a piece of colored plastic to a paperweight made of clear plastic.* Sand the bottom of the paperweight on a belt sander, using medium grit sandpaper, and soak in glue for 10 minutes. Then take the paperweight out of the glue and place it on the level piece of colored plastic. Clamp together with spring clamps and allow to set 4 hours.

3. *Gluing a handle in a gavel head.* The end of the handle is turned to the same size as the hole in the gavel head. Use a medicine dropper to place glue in the hole; then, with a dowel, move it around to soak all surfaces of the hole. At the same time, the part of the handle to be glued in the head is soaked in glue for ten minutes. Excess glue is drained off; then the pieces are held together by the use of a double bar clamp. Gluing time is 4 hours.

4. *Gluing, a joint in which the surfaces are not smooth, or one that might be considered a patched joint.* Use plastic dust from the sander, and ethylene

Three methods of gluing plastic—using a vise, a double bar clamp, and spring clamps.



dichloride, to make a thick paste-like glue. Apply on the surface to be glued and allow to set until the joint becomes hard. This may require as long as 48 hours, depending upon the amount of glue needed. Sand the joint smooth after the glue has completely hardened. This process is used to repair holes or cracks in plastic items.

5. *Gluing metal, masonry, or wood to plastic.* Apply epoxy-cement to both surfaces and let set for thirty seconds; then place glued surfaces together and allow to dry from 24 to 48 hours. No clamping is necessary. Care is to be taken to hold the parts in place. If the glue joint is a sign on a vertical wall, tape will be needed to hold the plastic in shape.

6. *Gluing hot plastic to cold plastic.* This joint is used when fastening items such as pictures or emblems between two pieces of plastic. Proceed as follows:

- Heat one of the pieces.
- Place item to be enclosed on a hot piece.
- Wet the outer edge of the cold piece with plastic glue.
- Place in a jig and vise to press outer edge firmly.

A common problem in fastening hot plastic to cold plastic arises when one piece of plastic is not level:

- Heat unlevel piece.
- Soak level piece in glue for ten minutes.
- Place the hot piece on the cold piece between two level blocks.
- Clamp in a vise and allow to set for 30 minutes.

7. When it is necessary to glue plastic *without the use of clamps,* soak the surfaces to be joined in plastic glue for 10 minutes. Then hold them out of the glue 30 or 40 seconds, allowing the excess to drain off so that it will not run onto outer surfaces. Hold the parts together by hand for 2 minutes to assure that they do not move before the glue starts to set.

8. *In making signs,* glue joints must be strong. Place a tablespoonful of plastic dust from the sander in the letter where the bracket is to be glued; wet the dust with the ethylene dichloride to make a gluey substance in which to place the bracket. After the bracket has been placed correctly, allow to dry for 48 hours. No clamps are necessary.

When the sign is to be glued onto a building, it will require an epoxy-cement glue, or some other good, all-purpose glue, on the bracket and on the wall where the bracket is to be placed. The letters are kept in place by masking tape for 24 hours.

9. You should find the use of *colored glue* fascinating. Coloring is added by mixing powdered plastic dye in ethylene dichloride. One tablespoonful of plastic dye powder is sufficient for a gallon of glue. For a variety of colors, the three primary hues, red, yellow, and blue, are mixed in different containers and then the desired tones of other colors are made. For example, green glue is made

Here colored glue is used to make a plastic walking stick. The work-holding devices keep the plastic in place while the glue hardens.

by mixing the yellow and blue. Colored glue is thickened by dissolving clear plastic in it. When glue is not thick enough, it tends to run.

Colored glue is used only on clear plastic. To secure a joint with colored glue, soak one surface in clear glue for 2 minutes and apply the colored glue to the other surface with a small brush. Then clamp together with spring clamps. If more than one color is used in the gluing, do not allow the plastic to move, or the hues will be mixed.

Some common uses of colored glue are on boxtops, bases for penholders, key chain fobs, necklaces, lamp bases, salt and pepper shakers, bookends, and walking sticks.

Remember, after you have learned the methods to follow in making glue joints, you still need practice in using materials and tools to become truly skillful.

The kind of joint needed and the type of plastic used will be factors in the selection of glue. Ethylene dichloride is one of the glues used for general purposes in working with acrylic plastics. Another is one half methylene dichloride and one half methyl methacrylate monomer. Before using any plastic glue that contains monomer, one or two drops per ounce of an oxidizing catalyst are added, per ounce of hydroquinene. This will prevent polymerization of the monomer while the glue is stored or not in use.

Jigs for holding parts should be used when making a glue joint if even, controlled pressure cannot be assured with the other tools such as clamps, weights, and vises. The control is necessary because too much pressure will push the cushion out of the joint. This cushion is the result of soaking the plastic in the glue. Too much pressure will cause crazing. Two to three pounds per square inch is

sufficient pressure to glue where pressure is needed. Many times pressure is not needed at all for gluing. One example would be a crack that is being cemented. In this case the glue and clear plastic dust are mixed to form a paste.

The *spring jig* and *spring clamp* are used in cushioned joints because, as the soaked parts harden, they draw away from the clamp, thus requiring a spring to maintain pressure.

Plastics are bonded together by *heat* in some instances. This may be done by different methods. One is placing the two edges against an electrically heated blade and, when the plastic becomes soft, taking the blade out and pushing the edges together. Hold them in a spring jig. This should have a pressure of 2 to 3 pounds per square inch.

NOTE: The terms glue, cement, and adhesive solvent are interchangeable when describing working with plastic. Since this book includes the combining of plastics with other materials, *glue* is used as the general process term.

Questions on Gluing

1. What is a good glue joint?
2. What mixture is recommended for a strong, clear glue joint with acrylic plastics?
3. When is a spring jig needed for gluing?
4. How many pounds of pressure are needed when the plastic has been soaked in glue, to secure a good joint?
5. What kind of a clamp is used to glue a handle in a gavel?
6. How is a crack repaired in a plastic item?
7. When letters are to be glued on a wall, what is used to keep them in place until the glue sets?
8. What type of glue is used to glue letters on a wall?
9. How is colored glue made?

12 ENGRAVING

Engraving a design on plastic is done with a tool that vibrates. The point goes up and down to cut the design in. The type of point determines the kind of lines the tool will cut. If a very fine line is wanted, a fine point is put in the tool. If a heavy line is wanted, a blunt point is used.

In preparation for engraving a design in clear plastic, select the proper design plan or pattern, fasten it on the underside of the plastic with cellophane tape, and then put the proper point in the vibrating tool.

To engrave the design, hold the tool straight down upon the plastic. The tool will not do a good job if it is not going straight down.

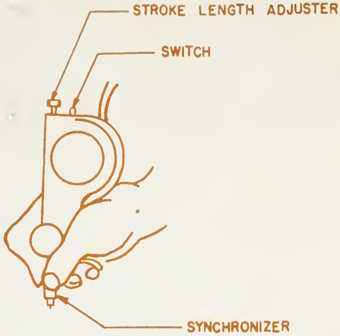
Using "Vibro" tool for engraving design on tray.

Follow each line carefully, cutting each one the desired amount. For a design using light lines, the weight of the tool is sufficient, but if heavier lines are to be engraved a small amount of pressure is applied. The tool actually only "scars" the polished surface. After all lines have been cut in, check to see that all are cut as desired before removing the design pattern, since it would be hard to get the pattern back under the plastic in the original position in case part of the engraving is not properly done.

In the cutting of a design on a colored piece of plastic, which cannot be seen through, the design is traced on by the use of carbon paper, or traced on thin tracing paper. This thin paper is then fastened on the top of the plastic and the worker goes over the design with the etching tool. This must be done very carefully to make sure the tool has cut through the paper and into the plastic the desired amount before removing the pattern.

This type of work is done in the making of *trays* and *plaques*.

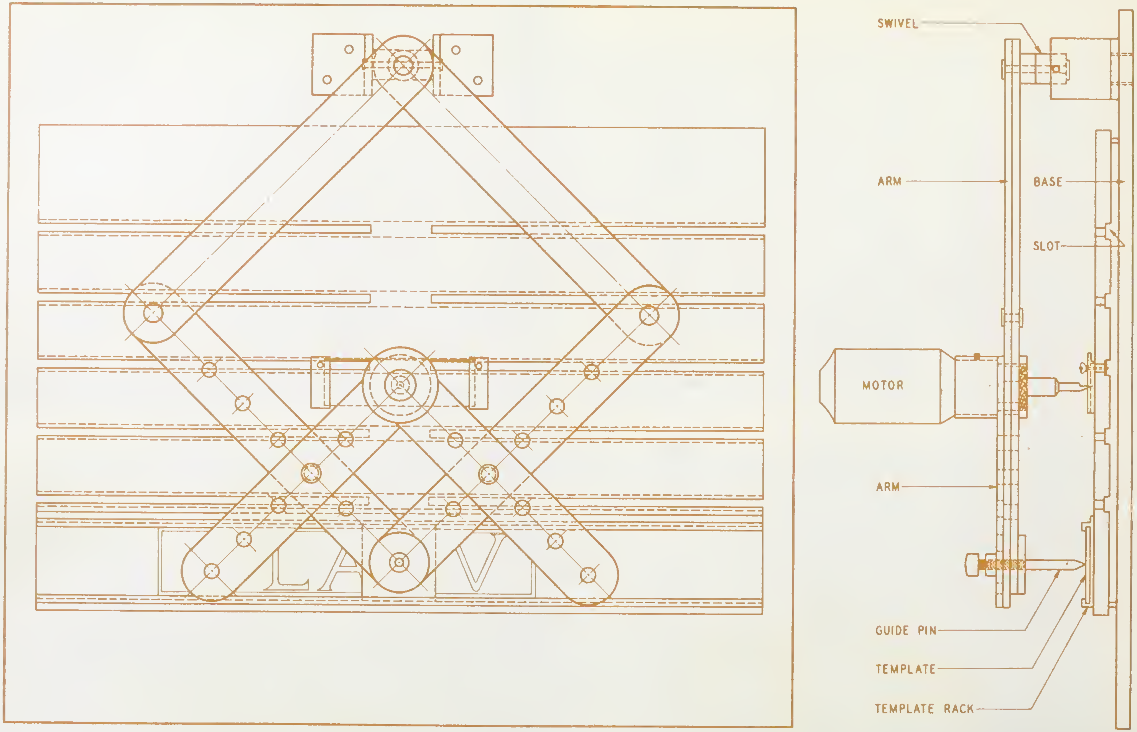
Another use for the engraving tool is for writing on plastic when the letters do not need to be uniform. This is often done in the writing of a name on a bracelet, luggage tag, etc., and must be done while the plastic is flat. For example, in making a bracelet on which you wish to write the name *Mary,* write the name on after the piece is polished and before heating to shape.



Holding the "Vibro" tool.

The choosing of the design to match the project and plastic is important. For example, do not choose a design that completely covers the plastic. And do not put a very small design on a large piece. Also the design, or the writing, should be evenly spaced.

Letter file with engraved design.



Engraving machine. Made from aluminum and plywood. Powered with a portable drill, which can be detached and used for carving.

Strive to keep the plastic clean and free of scars after cutting the design in. The lines that have been cut become white, and if they are scarred and the design is buffed, the effect will be to dim the lines and give them an irregular appearance.

Questions on Engraving

1. What kind of a tool is used to do engraving on plastic?
2. Where is the design plan or pattern to be used placed when using clear plastic?
3. How is the pattern used on colored plastic?
4. Why be sure the design is cut in the plastic in all parts before taking the pattern off?
5. Why not buff after a design has been etched on?
6. What should be kept in mind while choosing a design?
7. What use is found for the engraving tool other than for making designs?

• ***Engraving letters or numbers.***

The correct procedure for engraving letters or numbers depends upon whether the plastic into which the letters are carved is opaque or transparent.

Letters or numbers cut in transparent plastic may be cut in either of two ways. They may be cut in the regular order—that is, on the front side of the plastic. Or they may be cut on the back side so as to be seen through the plastic. If letters or numbers are cut on the back side, reverse templates are used. As a rule, back-side—that is, reverse lettering—is prettier in transparent plastic. But, of course, reverse letters cannot be used on opaque plastic, because it cannot be seen through. Therefore lettering on opaque plastic must be done with *templates reading right*. Letters cut in opaque plastic need a filler to make them show up. For instance, if the plastic is black, a white or gold filler (or paint) will make them show up well.

The machine is made of aluminum and plywood. It could be made of any size, to suit individual needs. The arms are made of aluminum: two back arms and two front arms of the same length, and two top arms, shorter than the others.

The base is made of two pieces of plywood, the bottom piece larger than the top. The top piece has slots cut in it where the clamps are placed for holding the plastic while it is being cut. Holes are drilled in the ends of the back arms in which to fasten the swivel, and in the other ends for fastening to the front arms, as shown on page 100. Likewise holes are drilled in the front arms for fastening to the back arms, and for fastening to the guide pin in front. Holes are drilled in the front arms and the top arms for varying the size of letters cut. The motor is mounted in a sleeve through the overlapping top arms.

A metal rack for holding the templates is made with slots on the sides in which the templates

Use of the engraving machine to make a name plate.

fit snugly, as shown above. The guide pin is a threaded bolt ground to a fine point for tracing the letters of the templates.

The majority of persons use salvage plastic obtained, directly or indirectly, from fabrication plants, rather than from dealers or manufacturers. The budget may be too small to buy plastic from dealers as first-grade material. But there are sources of

Sign made with the engraving machine.

salvage that the average budget can afford. This helps to achieve one of our objectives—that of economy.

Some of the salvage material obtained may have been molded and formed so that it is necessary to flatten it before attempting to engrave letters on it. This flattening can be done by placing the plastic in an oven and allowing it to heat until it becomes flexible. After the plastic becomes flexible in the oven, it is removed, placed between two flat surfaces, and allowed to cool.

When the plastic is ready for engraving, the machine is set for the desired size of letters. This is done by moving the cutter forward for larger letters or backward for smaller letters.

Then the letters are put in the rack and spaced correctly. Check to make sure that all letters are in and properly arranged. Here, too, put into practice your knowledge of spelling and punctuation. For when a mistake is made by wrong arrangement of letters, the work cannot be erased; the plastic is ruined.

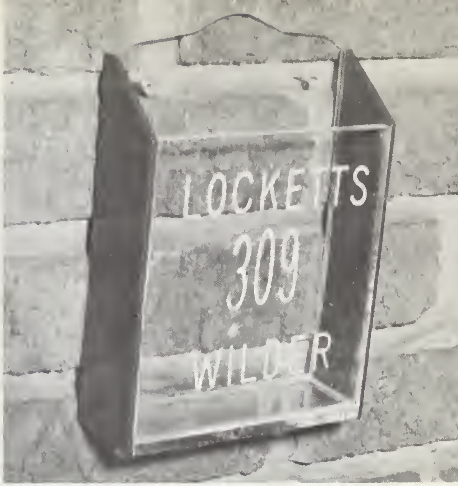
The plastic is placed under the cutter so that the spacing will be correct when the letters are cut. Before cutting, however, check the placement of the plastic in relation to the cutter to make sure that the lettering will be centered as desired.

Before starting to cut, make the plastic level and tight so that it will not move during the cutting process.

Turn the cutter up high enough not to touch the plastic when the guide pin is set down on the letters. (The cutter is adjusted up or down by screwing the guide pin up or down.) Before starting to cut, lower the cutter to the surface of the plastic by screwing down the guide pin. When the cutter touches the surface of the plastic, turn the guide pin another half turn, if a shallow cut is wanted, or a full turn if a deeper cut is wanted. The *depth of the cut* is determined by the thickness of the plastic and the size of the letters. After the desired set is made, the lock is turned on by use of the lock nut on the guide pin. This assures uniform depth of letters.

Now the cutting begins. The *guide pin* is raised, lifting the cutter off the plastic. Then the motor is turned on, and the guide pin set straight down at the beginning of the first letter. Then the letter is traced with the guide pin. This cuts the first letter in the plastic. The guide is now raised straight up and set back down on the next letter in the same manner as before, and so the cutting proceeds until all letters are cut.

After cutting all the letters, move the machine back so that the letters can be checked to see that they have been properly cut. If not, make the necessary corrections before moving the plastic. If a portion of a letter is too shallow, due to improper use of the guide, make it as deep as the others now, before the plastic is moved. For if the plastic is moved



Mail box, showing another use of the engraving machine.

Trophy for hiking.

out of position, it is very hard to get it back into the exact position it was in before.

If the letters are to be filled with paint or filler, do the work with a small brush, using well-stirred paint.

WARNING: Use the proper brush. A brush that has been used for red must not be used to apply green paint. Apply the paint heavily. Any excess paint that gets on the plastic is not rubbed off while it is wet, but can be buffed off after it is dry. After use, the paintbrush is cleaned with paint remover and put back in its proper place. Also put away the paint container in its usual place. Always put tools or equipment back in their proper places after using them.

Questions on Engraving Letters or Numbers

1. What is the difference between reversed lettering and lettering reading right?
2. When should reversed templates be used?
3. When should templates reading right be used?
4. What should be done to plastic that is not level before engraving on it?
5. Why should the plastic be spaced correctly?
6. Why should the plastic be fastened down *well?*
7. How can one determine the proper size letters?
8. How is the correct depth achieved?
9. What kind of plastic requires paint in the letters?
10. How should the paint be put in the letters?
11. What care should be taken of the paintbrush?
12. How is the engraving machine adjusted for correct depth?
13. With what part of the machine are the templates traced?
14. How is the size of engraved letters varied?

13 PIPE FITTING AND WELDING

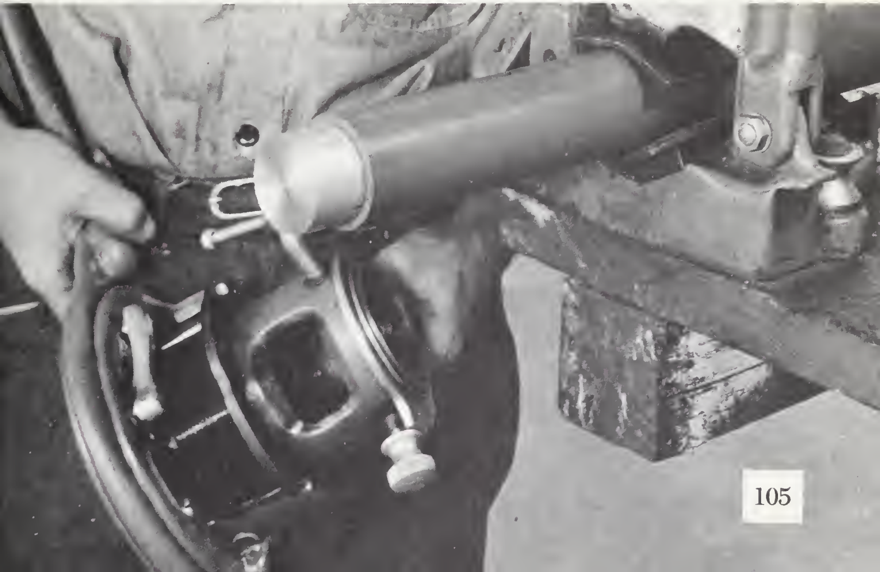
Pipes made of plastic are becoming very widely used today due to their corrosion resistance, ability to bend easily, and, in some instances, their cheapness. Plastic pipes also are supplied in long lengths in the form of coils, thus making it possible for the number of joints to be held to a minimum.

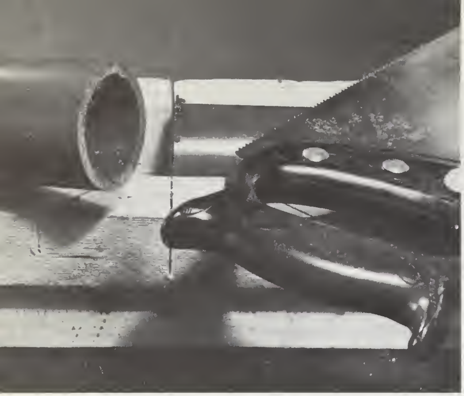
The three major methods of plastic pipe fitting are: threading, solvent cementing, and welding.

- ***Threading.***

Threading is done with a pipe threading machine or standard hand pipe taps. Dies with a front rake angle of 5 to 10 degrees will give the best results. A wood or metal plug of greater length than the amount to be threaded must be inserted into the pipe before threading. This plug is to support the pipe and hold it round. When using a vise, the pipe is protected with a metal sleeve or canvas

Showing plug assembled in pipe for threading.





Sawn plastic pipe.

Threading plastic pipe.

wrap. The dies must be clean and sharp, and the cuttings must be kept washed away.

The procedure to follow for pipe fitting by the threading method is as follows:

1. Insert the plug. Use a metal sleeve or canvas wrap at the vise for protection.

2. Saw the pipe to the desired dimensions, being sure the cut is square. Use either a crosscut hand saw, a miter saw, or a power saw. The saw is fine toothed, 6 to 9 teeth per inch, with very little or no set.

3. Smooth the cut end with a file and remove all filings.

Filing plastic pipe.

TUBE TURNS PLASTICS, INC.

Applying thread lubricant to pipe fitting.

4. Thread the pipe with a steel pipe die.

5. Clean the cuttings off.

6. Apply lubricant to the threads. This is inserted on the inner and outer fitting and serves both as a lubricant and as a seal.

7. Wrap tape on the threads. Or . . .

8. Brush cement evenly over the male threads and screw the fitting on the pipe. (NOTE: Steps 7 and 8 are *alternates.*)

9. Use a strap wrench to turn the fitting two to four turns past hand-tight.

10. Avoid moving the pipe for 30 minutes. Forty-eight hours setting is required for full strength of the joint.

Applying tape on threads for pipe fitting.

- ***Solvent-cement fitting.***

Use of solvent cement is an effective method of sealing plastic pipe. Small pipes are fitted by the solvent method more than by any other.

Applying cement.

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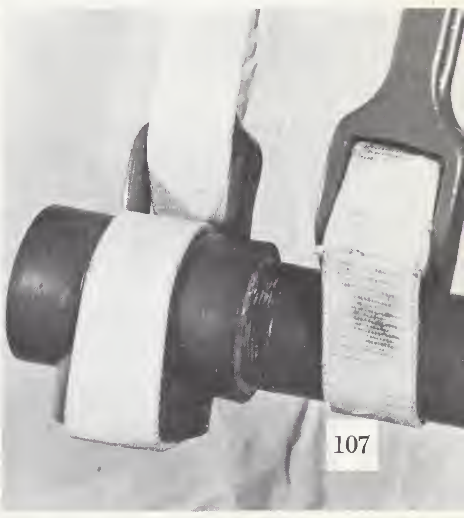
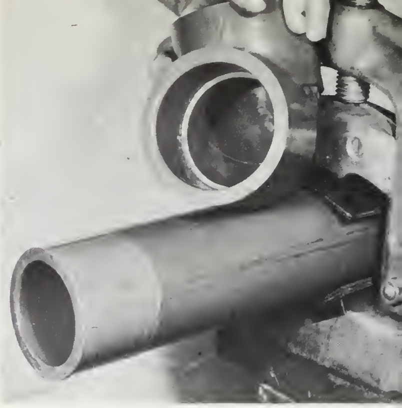
Using the strap wrench. Showing clamps for assembling pipes.



Cleaning the pipe with acetone before cementing.



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Prepared parts for solvent cement fitting.

See illustrations on pages 107, 108, and 109, and procedures connected with them, for full details.

If the pipe is too large to fit as a joint, emery cloth is used to remove excess material so as to provide a proper fit. All connecting surfaces should be cleaned and free of dirt and grease. Acetone is a good cleaning agent.

The solvent-cement procedure is as follows:

1. Insert a plug of wood to keep the pipe round and firm for sawing.

2. Wrap the portion of the pipe that is to be in the vise with canvas for protection.

3. Saw the pipe square, using a fine-tooth saw.

Applying solvent cement for pipe fitting.

Assembling solvent cemented parts in pipe fitting.

TUBE TURNS PLASTICS, INC.

4. Smooth the end with a file.

5. Sand the pipe with emery cloth, if needed for a good fit.

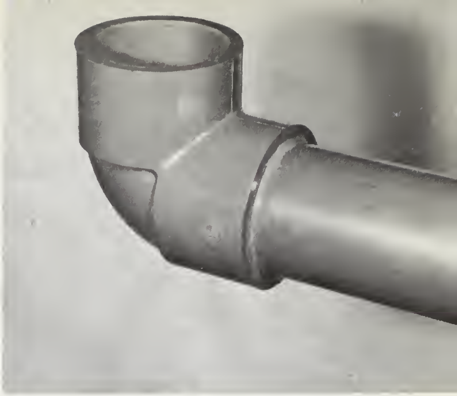
6. Wash the filings and the dust off the pipe.

7. Clean connecting surfaces of both the pipe and fitting with a cloth moistened with acetone.

8. Apply solvent cement to both connecting surfaces. Use generously so that the entire surface will be filled. The cement must be a solvent of the same plastic as in the pipe.

9. Push the fitting together and turn the pipe one half turn to distribute the cement.

10. The pipe can be moved, with care, after 30 minutes, but do not put excess strain on it until after 48 hours, when the joint reaches maximum strength.



Assembled fitting by solvent cement.

- ***Welding pipes.***

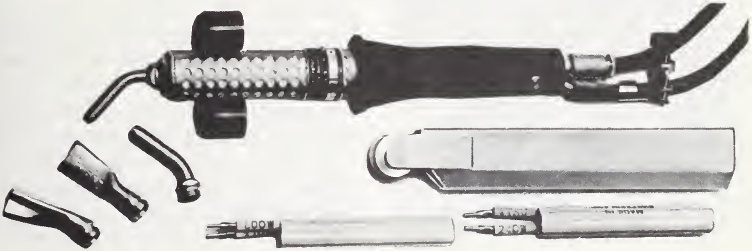
Welding plastic pipes is accomplished by means of a hot air gun or torch. Welding guns may be heated either by gas or electricity. The electrically heated gun is the most convenient.

Welding is the art of uniting two or more components of the same material under the influence of heat and pressure.

To prepare for welding, the pieces are cut and formed into the proper shape. In welding a butt joint, a beveled angle of 30 degrees is cut or filed. Internal corner sections are beveled to 45 degree angles. The material is cleaned and all sharp edges filed round. *Solvent is not used*, since this causes the material to soften and will result in a poor weld.

Plastic welder and attachments.

SEELYE PLASTIC FABRICATING, INC.



This procedure is followed in welding plastic:

1. *Tack weld.* The purpose is to hold in place the pieces that are to be welded. The tack weld has very little tensile strength.

Air pressure should be about 3 pounds. The temperature of the tip is approximately 600 degrees F. The temperature at the actual welding point is approximately 450 degrees F.

2. Hold the welder in one hand and the welding rod in the other. The rod must be of the *same material* as the pieces to be welded.

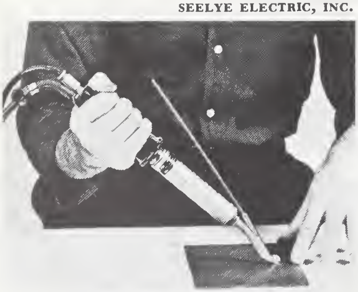
3. At the start, the tip is about one half inch above the base material and at a 45 degree angle.

4. Move the tip in a fanning motion along the areas to be welded. This is to pre-heat the base material, to avoid charring or browning it.

5. Place the end of the welding rod on the pre-heated area and continue the fanning motion.

Welding plastic with a round tip and a round rod.

SEELYE ELECTRIC, INC.



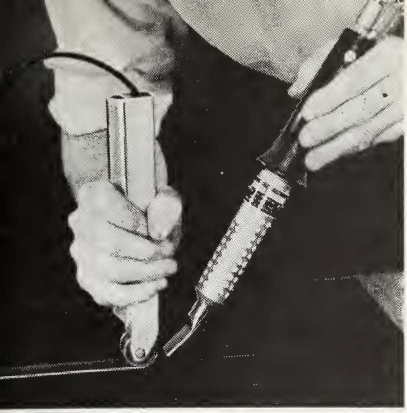
6. Apply gentle pressure to the rod, moving it as it gives from heat. If the welding rod and gun are moved *too slowly*, the welded area will discolor or burn. If the weld progresses *too fast* the flow-lines along the rod will not appear. (These flow lines indicate that the material is at the proper temperature to weld.) This is the result of not heating the weld long enough to assure a good weld. There should be a uniformity of flow lines along both sides of the welding rod without any discoloring or burning. To end the weld, move the welder to an upright position and cut off the rod with the point.

The welding process is used in other fabrications, such as of large signs and odd shaped housings where bonding or cementing is difficult.

In order to do a good job of welding, it is necessary to practice, just as it is necessary to practice driving a car. Holding the welder and rod at the proper angle takes as much practice as moving the welder and rod at the proper speed.

The type of tip to be used will depend on the type of welding material used. For example, a round tip is used with a round welding rod and a flat tip is used with a strip.

Some plastic welders are equipped with accessories for butt welding of pipes, cutting plastic ropes, cutting plastic fabrics, hot welding, film sealing, and patching.



Using a welder with a flat strip to weld over a butt joint.

SEELYE PLASTIC FABRICATING, INC.

Using a plastic welder with a curved tip to weld an angle of plastic pipe.

Butt welding of plastic pipe is done by assembling the blade attachment on the welder and clamping it in a vise. The welder will heat the blade to approximately 520° F. The ends of the pipes are cut square and smooth and placed against the blade lightly until the material softens, when it starts to smoke. The ends are then placed together and held until they cool.

Plastic fabrics are cut with the welder by placing the fabrics on a table and moving the heated tip down the material. This method seals the edges from the heat, making hemming unnecessary.

Lap welding is accomplished by passing the angle tip between two edges that are overlapped and pressed together. This is recommended only on thin material.

Film sealing with the welder is needed where large covers are used, as for tanks.

Patching with the welder is done by placing a piece of the same type plastic over a hole in an item and heating around the edges. If the material is thick, a welding rod is used. In case of a small defect, it can often be repaired simply by rubbing the heated welder tip over the defect.

Questions on Pipe Fitting and Welding

1. What are the three major methods of pipe fitting?
2. How is the pipe protected when it is clamped in a vise?
3. What kind of saw is used to cut plastic pipe?
4. Why is a plug of wood used in the pipe while sawing and filing?
5. What type of cement should be used in fitting pipe?
6. What is welding?
7. What is the purpose of tack welding?
8. How much air pressure is needed for welding?

9. What is the needed temperature at the welding point?

10. What is wrong when discoloring or burning appears along the welding joint?

11. How is butt welding accomplished?

12. Why is the welder good for cutting plastic fabrics?

13. How is lap welding accomplished?

14. How may a plastic item be patched with a welder?

14 TURNING PLASTIC

Turning plastic requires not only correct procedure but skill developed by practice. First, one must learn the correct procedure to follow. Secondly, he must develop skill by correct practice.

There are two types of turning: (1) cylinder turning and (2) face-plate turning.

• *Cylinder turning.*

Cylinder turning requires the following preparations:

1. Cut the stock to be turned 1 inch longer than required to produce the desired project. This is because the live center and the dead center must be connected to the ends, which will as a rule damage the ends so that they cannot be used as part of the project.

2. Determine positions of live center and dead center by drawing diagonal lines from corner to corner. See illustration page 114. Where these lines cross is the center. A hole is drilled in each end to a depth of ¼ inch with a ⅛ inch drill. In the end to be used for the live center a saw kerf ⅛ inch deep is sawed where the lines are. This is for the prongs of the live center.

3. The corners are ground off on a coarse belt or disc sander, so as to make the plastic as nearly round as possible. This is because plastic chips and breaks easily when turning sharp corners round.

4. Fasten the plastic in the lathe by placing it in the live center. Then move the tailstock up to where the dead center goes in the hole at the other end. The tailstock is fastened so as not to move.

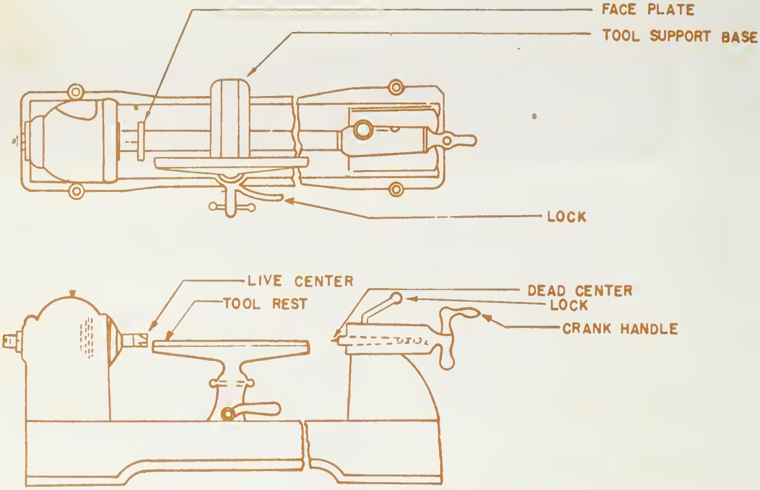
5. Put oil in the hole of the dead center. This is done to prevent heating of the plastic while it turns around.

6. Move the guard up to where the turning tool can best be used on it; and be sure it is fastened by use of the handle clamp, so as not to move while the lathe is running.

7. Choose the correct *tool* to start with. The tool to use on plastic should be one that will give a scraping, not a chipping cut, because plastic is easy to chip. These are the skew, the round-nose gouge, the parting tool, and the marking tool.

8. Turn the lathe around one time by hand to see that it has clearance from the guide all the way around.

9. Check to see that the belt is in the proper groove of the pulley to give the correct speed—1,400



Main details of a lathe.

rpm to 1,725 rpm. To reduce speed, change the belt to a smaller groove of the motor pulley. If too slow, change to a larger groove.

10. Turn on the motor and place the tool on the guide, holding the handle down at one side with one hand. With the other hand hold the tool on the top of the guide, with the forefinger moving in the groove of the guide. (The handle is down by the side to assure safety in case the tool catches in the plastic; also the student will have better control over the tool.)

11. Apply the tool to the plastic gradually, so as to cut a small portion at first. The cuts will be irregular until the plastic has been cut round. The plastic will appear to be round before it is, while the machine is running. The only way to know when it *is* round is to observe the shavings. When the shavings come off in long ribbons, the plastic is round.

12. For better control of the tool in cutting, hold the handle against the *side of the body,* not merely in the hands.

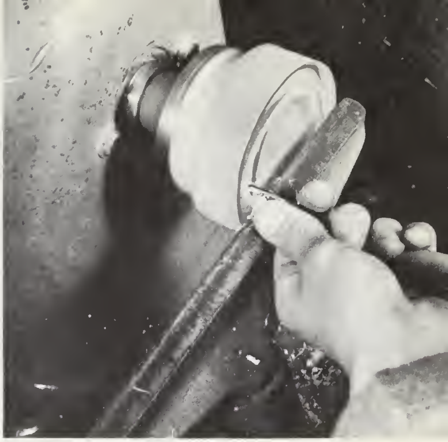
13. Wear *goggles* while turning plastic.

14. Keep tools sharp by grinding and whetting on oilstones so that they will cut a smooth surface.

15. As the design nears the desired shape, apply light pressure with the cutting tool so as to produce a smooth surface rather than a jagged one, thus reducing sanding time.

16. Sanding is done on the lathe by moving the guide away and holding sandpaper lightly on the plastic as it turns around, starting with coarse sandpaper and using finer as the stock gets smoother. Take care not to change the desired design by sanding small cuts and grooves out of the design.

When sanding has been completed, take the plastic off the lathe and cut off the waste portions of the ends. When this is done, sand the ends on the machine sander and by hand. Then the entire portion is ready to buff.



Faceplate turning.

• ***Faceplate turning.***

The plastic may be fastened on the faceplate by screws if it can be done without showing the screw holes in the finished product. If the finished material would show the screw holes, a piece of wood may be glued on without removing the masking paper, then the faceplate fastened onto the wood. However, this glued-on wood is not a strong glue joint and may come loose if heavy cutting is done. Therefore, when material is fastened onto the faceplate in this manner, the material must be cut slowly and easily by

Steps in preparing for turning plastic.

Turning plastic in a wood lathe.

cutting a small portion at a time. The glue used must be one that will glue both paper and wood.

Turning on the faceplate has the same requirements, as to tools and guide, as cylinder turning.

Plastic of different colors may be glued into one piece to be turned. This can be done in such a way as to give lovely color designs. Also lettering may be engraved on colored plastic and the engraved piece glued between two clear pieces so as to show the letters on the inside after turning has been completed. For example, the letters PTA (Parent-Teachers Association) may be engraved on a piece of black plastic ¼ x 2¼ x 3½ inches, using gold or white paint in the letters and allowing it to dry. Then this lettered black piece is glued between two pieces of crystal plastic 1 x 2¼ x 3½ inches. After the glued joint has dried, the block so made can be turned to make the head of a gavel.

Also a fraternal emblem may be put in the head of a gavel in the same manner. Gold or bronze paint is suggested for the emblem, and white paint is suggested for lettering when black or green plastic is used.

• *Turning plastic on a metal lathe.*

Turning plastic on the metal lathe requires correct procedures and adjustments, accurate timing, and an understanding of the purpose of each part of the metal lathe. Candle holders can be made with the metal lathe. You will need two black discs, ¼ x 2¾ inches, and one piece of plastic, 1¾ x 1¾ x 16¼ inches. Acrylite and Plexiglas are good plastics for turning.

Procedure

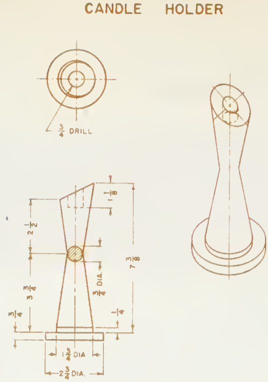
1. Cut the stock to be turned 2 inches longer than required to produce both candle holders. (Connecting the live center and chuck will often damage the ends so that they cannot be used. Also, part of this material will be used in the center where the two candle holders are separated.)

2. Cut the stock square to assure centering the plastic in the chuck and tailstock.

3. Determine the position of dead center by drawing diagonal lines from corner to corner. The lines will cross at center. Drill a ¼ inch hole at center with a ⅛ inch drill.

4. Fasten the other end of the plastic in a 3- or 4-jaw chuck. Sand the portion of the plastic round if a

Plastic candle holders, which are turned on the metal lathe.



Drawings for candle holder.

3-jaw chuck is used. Tighten the jaws around the solid part of the plastic. Be sure the set screws are tightening on a solid surface. The set screws are to be ⅛ inch from the end. Make sure the chuck is clean before it is used. CAUTION: Use only the chuck wrench to tighten the chuck jaws onto the plastic.

5. Fasten the plastic in the lathe by assembling the chuck and the plastic onto the head of the lathe. Then move the tailstock up to where the tailstock center goes in the hole at the other end. The tailstock is fastened so it will not move. A live center in the tailstock is best for turning plastic. However, if a dead center is used, apply two or three drops of oil on the point of the dead center. This oil serves as a coolant to keep the plastic from getting hot around the dead center.

6. Select and assemble the cutting tool in the tool post. There are left-hand, right-hand, and straight tool holders. Use the straight tool holder.

7. Loosen the carriage lock screw and turn the apron handwheel, noting how the carriage assembly moves up and down the lathe base. Place the carriage in the desired position.

8. Adjust the compound slide. The top slide is a swivel slide, enabling it to be moved in and out as well as in a circular movement. Turn the handle of the cross slide so as to move the compound slide up to the plastic.

9. Adjust the cutting tool so it lines up with the center of the plastic. Then move the carriage so the cutting tool will be at the tailstock end of the plastic.

10. Set the cutter to cut the desired depth, as much as ⅛ inch. For the first run, leave the carriage assembly clutch out and move the carriage by turning the apron handwheel by hand for the first cut. If the adjustments are not accurate, the error can be detected and necessary corrections made without damage to the lathe or plastic.

11. Selection of the speed is al-

ways important. It is best to go slowly when first using a machine.

12. Set the cutter for the second run. Now turn the clutch knob and the carriage will move the assembly down the stock for the second run. Repeat until the plastic is turned round.

13. Cut the lathe motor off. Then measure and mark the plastic for the desired design.

14. To cut the design, it is suggested that the clutch be released and the design be cut by moving the carriage and slide by hand. IMPORTANT: The carriage lock screw is tightened only when the carriage is not to be moved. For example, the tool is moved by feeding the cross slide or compound slide.

15. Move the carriage assembly back next to the tailstock and sand the plastic. A good speed for sanding is 1700 rpm. If a smooth turning job has been accomplished, only fine sandpaper is needed.

16. Remove the plastic from the lathe. Clean the plastic dust off the lathe parts — with an air hose or a vacuum cleaner if possible.

17. Cut the waste portions off the plastic, using the bandsaw or the circle saw.

18. Drill a 1⅛ inch hole for the candle with a ¾ inch drill.

19. Using a disc sander, sand the top down at the desired angle. Then sand the bottom level.

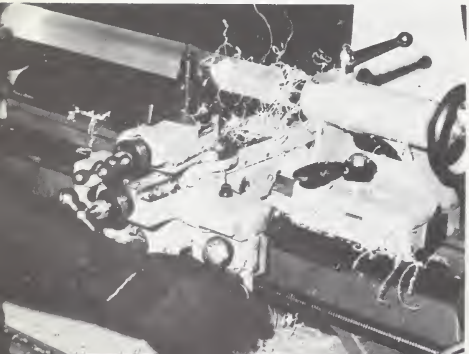
20 Mark off and saw out two discs, ¼ x 2¾ inches in diameter. Use the band saw.

21. Using the disc sander, sand the edges smooth. Then hand sand and buff to a high polish.

22. Buff the uprights to a high polish. Do not buff the bottom since smoothly sanded surfaces make stronger cement joints.

23. Using ethylene dichloride, cement the uprights to the base. Etylene dichloride, thickened with plastic dust, makes a strong glue joint.

Turning plastic on a metal cutting lathe.



Questions on Turning Plastic

1. What are the two types of turning?

2. In cylinder turning why should the stock be cut longer than desired for the project?

3. How are the centers on the ends found?

4. How deep are holes drilled for the live and dead centers?

5. What is to be done to the end for the live center?

6. Why should the corners be sanded off before assembling the plastic in the lathe?

7. What kind of turning tools are to be used in turning plastic?

15 HAND TOOLS

There are a few hand tools that will be used often in the plastic shop. The scraper is the most used of these tools.

- ***The plane iron scraper.***

The best type of scraper is a plane iron. It should be kept sharp and free of gaps at all times. The way to tell when it is sharp is to touch the cutting edge lightly with the thumb. If it is sharp, it will take hold of the skin of the thumb. If not, the skin of the thumb will resist the edge.

- ***Use of the plane iron.***

To use the plane iron, the plastic is put in a vise in such a way that the worker can get to it and not touch the vise with the tool.

Scraping with a plane iron is done just after machine sanding and before hand sanding to remove the large streaks made by machine sanding. This scraping reduces the work of hand sanding.

The scraping is always done on a flat and straight surface. The proper method is to hold the plane iron with both hands and place it down lightly on the plastic. If you should set the cutting edge down hard, it will make a small but deep cut in the plastic. The correct method of using the scraper is to place it on the plastic so that the cutting edge will not be first to touch the plastic. Then angle the cutter up nearly to a 90 degree angle. The scraping is then done by pulling or pushing the scraper, with the beveled edge away from the body in pulling, toward the body in pushing. Scrape as long as white streaks can be seen.

Often in scraping, waves will appear in the plastic. These are caused by the plastic having gaps in it when the scraping is started, which should never be. Or gaps may be caused by putting too much pressure on the scraper. When waves appear, the only way to get them out is to sand them out on the machine sander.

- ***Try square.***

The try square is another valuable hand tool. It is a simple tool to use, and should be used often when sanding a piece of plastic to get it square or keep it square. To use the try square, there should be at least one smooth surface to put the handle on. This is called the *working surface.*

Put the try square on the plastic to see where to cut down, and check often in the process of sanding on the machine sander. By holding the try square flush with

the working surface, the blade will indicate where sanding needs to be done on the other surfaces adjoining the working surface. When they are true, all may be checked.

The ruler is used often in checking for proper dimension. Never put a mark on the ruler. One is often tempted to do so. Extra marks on a ruler might be misleading in its future use.

To divide a piece of plastic into *three equal parts* is hard to do. For example, a piece 11⅜ inches is to be divided into three equal parts. This can be done by placing the ruler diagonally so that the 0 inch mark of the ruler is at one end and the 12 inch mark at the other end. Then by marking off into three portions, with perpendicular lines, the piece is equally divided.

Sandpaper is considered a tool by some craftsmen. Whether classed a tool or a supply, it is important in plastics work. Hand sanding is done with fine sandpaper, ranging in fineness from a grit of 320 to 400.

If the surface to be sanded is small and uneven, the sandpaper is applied to the plastic where the small streaks are. This process is used to get the plastic ready for the buffer. As long as there are white streaks in the material, hand sanding is not completed. Often it seems that the hand sanding is putting in more streaks. This appears to be true because the sanding fills the streaks with white dust and causes them to show up to the eye. But the sanding should be continued until all white streaks are out. Persons who attempt to buff out some of the white streaks, instead of sanding them out, will only lose time for themselves and the machines.

Questions on Hand Tools

1. What is the most used hand tool?
2. How can one be sure that the plane iron is sharp?
3. How is the plane iron to be used?
4. What causes waves while scraping?
5. How should the waves be taken out?
6. What is the use of the try square?
7. Why should a ruler never be marked?
8. How can a worker know when he has hand sanded enough?
9. What is wrong with buffing out streaks?

Table 5

Table of Weights for Acrylic Plastics

Thickness (inches)	*Approximate Weight per Sq. Ft. (lbs.)*
1/16	0.4
1/8	0.8
3/16	1.2
1/4	1.5
3/8	2.3
1/2	3.1
3/4	4.6
1	6.2
1 1/4	7.7
1 1/2	9.2
2	12.3
2 1/2	15.4

16 EXPERIMENTING WITH PLASTIC

As said in Chapter 1, plastics are available in the form of sheets, rods, tubes, foam, granules, powder, pellets, and liquid; thermoset and thermoplastic are the two main classes of plastics.

Powders, pellets, and liquids are basic to the shop experiment laboratory. To get a better understanding of the properties and uses of the many different types, it it advisable to work with them in the shop laboratory. Also see Chapters 1 and 2.

• ***Materials needed.***

1. Thermoplastic and thermosetting plastic in the form of:
   • liquid—clear and colors.
   • powder—clear and colors.
   • pellets—clear and colors.
   • sheets—clear and colors.
   • foam—clear and colors.
2. Dyes in paste, liquid, and powder form.
3. Acetone.
4. Ethylene dichloride.
5. Methyl-ethyl-detone (or MEK) peroxide.
6. Medicine droppers.
7. Pans, many shapes and sizes.
8. Gloves.
9. Wax crayons.
10. Sheet metal.
11. Paper towels.
12. Mixing sticks.
13. Paper cups.
14. Paraffin.
15. Paint brushes.
16. Polyethylene bag.
17. Aluminum foil.
18. Hypodermic needle.
19. "Castolite" casting kit.
20. "Castoglas" kit.
21. Polyethylene film.
22. Mold release.
23. Fiber glass cloth or fiber.
24. Molding clay.

Although many different colored materials are available, dyes should be used in the experiments. Who knows, you may develop a more suitable color shade for your particular needs than can be purchased from a dealer.

• ***Mixing colors.***

Several paper cups and small brushes are needed to experiment with the dyes in deciding on colors and shades.

In mixing paste dyes, the three primary colors are used to get other desired hues. For example, red and blue mix to form purple. After testing, you may want to add more blue dye, or you may favor more red. Another combination of colors is blue and yellow

to form green. It is hard to tell just what tone the plastic will take until it has been tested on the plastic.

Powder dyes should first be dissolved in acetone or ethylene dichoride. Small beads will not dissolve, thus making uneven coloring. Powder or bead dyes are mixed in the same way as the paste dyes after they have been dissolved in the chosen solvent.

Several experiments are suggested here to help you become acquainted with some of the properties of plastics and uses of supplies in working with them, and to suggest other uses and procedures.

Experiment 1:

Testing time required for heating:

1. Select a cupcake tray; cover the inside of each cup with a thin coat of paraffin.
2. Place any amount of clear thermoplastic powder compound in one half of the cups and place a *different* amount in the others.
3. Place the tray in a pre-heated oven of 350 degrees F.
4. Check the results of this heating process every 5 minutes for 45 minutes.

- When fusing of the plastic occurs in each cup, place extra pellets in *one* cup for the last 5 minutes of heating time.
- Note when clarity appears in each cup.
- Note when clarity appears with ridges on the top surface.
- Note the cups in which blisters appeared in the plastic and at what heating time they appeared.

Experiment 2:

Testing for correct proportion of a catalyst to the resin:

1. Place one ounce of polyester resin plastic in each of three paper cups.
2. In one cup of the resin, put three drops of catalyst; in another put five drops, and in the third put eight drops. (Benzoyl-peroxide of MEK—is a good catalyst.)
3. Stir each of the cups of resin thoroughly.

- Note the time required for each cup of resin to gel.
- Note the time required for each cup of resin to harden. This is known as working time.
- Note difference in color after the resin has hardened.

Experiment 3:

Transferring a crayon design into plastic:

1. Select a pan the desired shape.
2. In the bottom of the pan draw the desired design with wax crayons.
3. Cover the areas that have not been covered by crayon with paraffin.
4. Cover the design with a clear plastic powder about 1/16 inch in thickness.
5. Place in a pre-heated oven of 350 degrees F.
6. Watch carefully and when the plastic has heated enough to fuse and show clarity, remove from the oven and allow to cool.

Experiment 3, transferring a crayon design into plastic, and *Experiment 12*, covering a picture with plastic pellets.

7. Remove the plastic from the pan by pressing lightly from the bottom.

8. The color design has melted and dissolved into the plastic.

9. Sand the edges and assemble screw eyes into the plastic.

This solid piece of plastic can be machined as needed, such as sawing, drilling, sanding, and buffing.

Experiment 4:

Design for table top:

1. Select a pan with the desired shape and size.

2. Cover the bottom of the pan with paraffin.

3. Draw trial designs on paper using various colors.

4. Determine the colors to be used in the desired design.

5. To color the plastic pellets as required, place them in paper cups, add the desired color, and mix.

Table tops made of clear plastic pellets.

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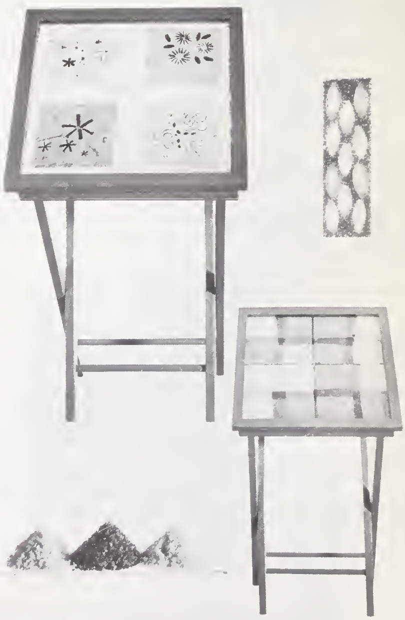


6. Place the colored and clear pellets in the pan to shape the design.

7. Place the pan in a pre-heated oven of 350 degrees F., and heat for 30 to 45 minutes.

8. Remove from the oven and allow to cool.

9. The plastic will cool in approximately 10 minutes, after which it is taken from the pan.

Experiment 5:

Coloring and shaping heated pellets by hand:

1. Select a tin cup; cover the inside with paraffin. (A cupcake pan is good for this experiment.)

2. Fill the cup to the desired height with clear plastic pellets.

3. Place in a pre-heated oven of 350 degrees F. for 45 minutes.

4. Remove from the oven and allow to cool for 3 to 5 minutes.

5. Remove from the cup and inject dye in the plastic before it cools, using a hypodermic needle.

6. At this temperature, you handle plastic the same as clay except it is hot enough to require gloves. Form the plastic to the desired shape with the hand.

7. Allow to cool until the plastic is hard.

Experiment 6:

Making a knife handle:

1. Sketch a suitable design.

2. Select a cup and cover the inside with paraffin.

3. Fill the cup with plastic pellets.

4. Place the cup in a pre-heated oven of 350 degrees F.

5. Watch the plastic; when it has fused, remove from the oven.

6. Using gloves, remove the plastic from the cup and shape as desired. A mold will bring best results.

7. Place the tang of the knife in the plastic. Will hold best if the tang is fitted with screws.

8. Place the plastic and knife in the pre-heated oven of 350 degrees F. and allow to heat long enough for the plastic to fuse. This will take about 5 minutes.

9. Remove from the oven and allow to cool and harden.

Experiment 7:

Three-dimensional art:

1. Select a pan large enough for a *plaque* and cover the bottom with paraffin, or with a crayon design, plus paraffin.

2. Cover the bottom of the pan about ⅛ inch with clear plastic pellets.

3. Select a smaller, narrow pan; cover the bottom with paraffin.

4. Add ½ inch of the desired colored plastic pellets.

5. Place both pans in a pre-heated oven of 350 degrees F.

6. Remove the plastic from the small narrow pan as soon as it has fused. Shape it as desired.

7. Place the shape from the small pan on the plastic in the large pan and heat both in the oven long enough for them to fuse. This will take 5 to 7 minutes.

8. Remove from the oven and allow to cool.

9. Remove from the pan and trim the edges.

Book ends made in *Experiments 8* and *14.*

EXPERIMENT 8:

Book ends:

1. Cut two pieces of hardwood 1 x 5 x 7 inches each.
2. Plane and sand the pieces smooth.
3. Make two frames 1/5 x 5 x 7 inches each from ½ inch molding.
4. Fasten the frames onto one surface of the wood pieces.
5. Place items of your own choice into the frames.
6. Cover the items and finish filling the frames with thermoplastic pellets.
7. Carefully place these parts of the book ends in a pre-heated oven of 350 to 400 degrees F.; allow to heat for 45 minutes.
8. Remove the items from the oven and allow to cool.
9. Join a piece of plastic 3 x 5 inches to one end, to make the bottom of the book ends.
10. Apply wood finish on the wood parts only.

EXPERIMENT 9:

Plaque of wood and plastic:

1. Cut a piece of hardwood ½ x 7 x 9 inches; plane and sand the wood smooth.
2. Make a frame 7 x 9 inches from ½ inch hardwood molding.
3. Fasten the frame onto the first piece of wood.
4. Place solid items such as

Experiment 9: Plaque of wood and plastic.

wood figures, copper wire, or metal shavings in the frame.

5. Fill the frame with plastic dust from the saw or sander.

6. Place color glues on the dust to make the desired designs. The glues are made from ethylene dichloride, dye powder, and plastic dust. Rit dye powder is sufficient.

7. Allow to dry for 24 hours.

Experiment 10:

Place-mat.

1. Draw a design on a piece of sheet metal, using wax crayons.

2. Any area that has not been covered by crayon is coated with paraffin. The wax crayon and the paraffin serve as a mold release.

3. Cover the design with 1/16 inch polyethylene powder. Microthene-710 resin is good. Various materials may be embedded for the design.

4. Place the metal with the design and plastic in the oven preheated at 350 degrees F.

5. The plastic will heat and fuse within 5 minutes. It is then taken out of the oven and allowed to cool.

6. Remove from the sheet metal; the result is a place mat with a translucent picture.

Experiment 11:

Room dividers:

1. Select metal pans of the desired shape and size, or make from aluminum foil.

2. Coat the pan or foil with paraffin to assure easy release.

3. Dye the clear plastic pellets to the desired color or colors.

4. Place pellets and items such as colored silhouettes in the pan.

5. Place in a pre-heated oven of 350 degrees F.; heat for 45 minutes.

6. Remove from the oven and allow to cool.

7. Heat screw eyes and insert them into the dividers for hanging purposes. The designs and items used in this process need not be limited. Uses may vary from place mats to bathroom wall plaques.

Experiment 12:

Embedding a picture:

1. Select a picture, such as from a magazine or calendar, to be embedded.

2. Select a pan of proper size for the picture.

3. Coat the bottom of the pan with paraffin.

4. Place a thin layer of clear plastic pellets in the pan.

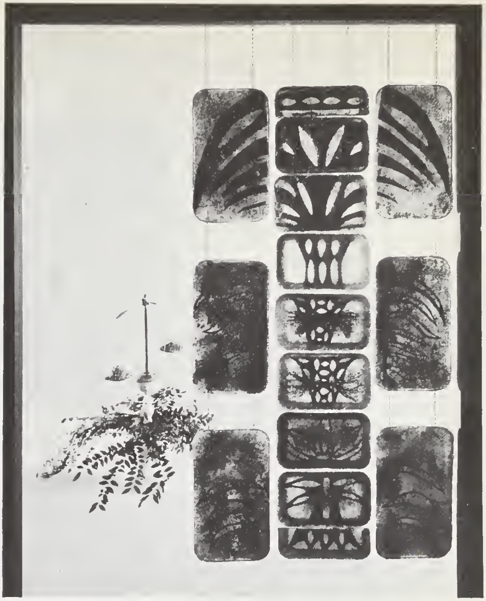
5. Place the picture on the pellets.

6. Cover the picture with a thin coat of pellets and arrange ridges of pellets to form waves over the picture.

7. Place the pan and its contents in a pre-heated oven of 350 degrees F.

8. Heat for 30 to 40 minutes or until the plastic pellets are fused and clear, showing the design on the picture.

9. Remove from the oven and allow to cool before taking the plastic out of the pan.



Room dividers in which clear plastic pellets are used.

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10. Note the ridged effect on the front surface due to the added pellets.

Experiment 13:

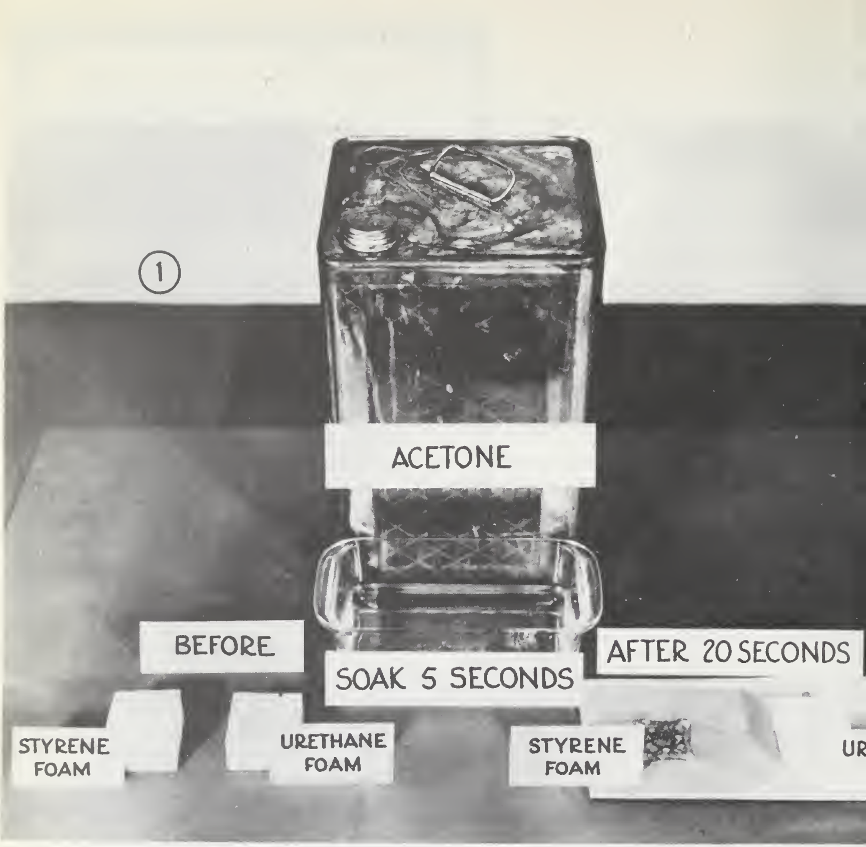
Art design:

1. Select a sheet of clear acrylic plastic of the proper size for the design.
2. Depending upon the number of colors, pour dye powder and sufficient acetone to dissolve, using a paper cup for each color.
3. Now pour into each cup sufficient polyester resin to satisfy the design. (This resin must have added 1 percent catalyst before mixing with the acetone.)
4. Mix the liquid dyes in each cup.
5. Using a medicine dropper, add the catalyst and mix thoroughly in each cup.
6. Using paint brushes, make the desired design on the clear plastic, using colored resin from the several cups. After the resin has jelled, it can be placed on the design to give the relief effect.
7. Allow to cure for 24 hours before moving.

Experiment 14:

Wood frame:

1. Make a wood frame as in Experiment 6. Finish the wood with shellac or lacquer.
2. Place wooden or other silhouettes in the frame.
3. Fill the inside of the frame with clear plastic dust from the band saw or sander.



Supplies for testing styrene foam and urethane foam plastics.

(The above illustration and those appearing on pages 129-132 are from an article by Robert R. Shields and James R. Harty in SCHOOL SHOP.)

4. Using a medicine dropper, cover the acrylic plastic dust with clear and colored glues. The colored glues are made of dye powder and ethylene dichloride.

5. Allow to cure for 48 hours.

This experiment allows you to try out the use of different colored glues in making a simple design. At the same time, the glues hold the dust in place.

EXPERIMENT 15:

Testing plastic foam with acetone or lacquer thinner:

1. Place one piece each of styrene foam and urethane foam, of equal size, into a pan.

2. Place paper towels on the work table.

3. Cover the plastic foam in the pan with acetone or lacquer thinner, for 5 seconds.

4. Place the foam pieces on the paper towels and observe the reaction of each piece.

EXPERIMENT 16:

Making foam plastic:

1. Using aluminum foil, make a container the desired shape and size. For example, a base for an ash tray, star for a Christmas tree, or backing for a wall picture.

2. Pour 50 percent urethane foam resin and 50 percent catalyst into the mixing container and mix rapidly. The working time will be from 20 to 40 seconds. As soon as you start feeling heat, pour the mixture in the aluminum container.

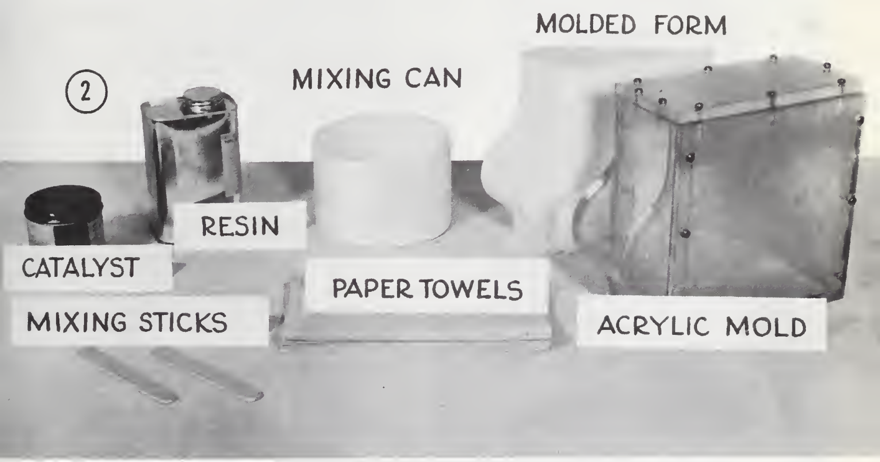
3. Do not disturb this container and mixture for 20 minutes. Twenty-four hours is needed for the foam to achieve its maximum qualities.

EXPERIMENT 17:

Embedding items in liquid plastic:

1. Determine the project to be made and the items to be embedded. The project may be fish flies embedded in a tie clasp and cuff links. Other suggestions are: embedding coins in a letter opener handle or a paperweight, and sea shells in ear screws or necklaces.

Items needed to make urethane foam plastic.



2. Make a mold of wood, plaster of paris, sheet metal, or aluminum foil. The type of project and the number of times the mold is to be used determine the type of mold.

3. Apply a release on the inside of the mold.

4. Mix castolite resin and a castolite promoter and hardener. Follow the directions of the supplier.

5. Mix the castolite resin with a catalyst. Two per cent catalyst is the usual amount. Follow the directions of the supplier.

6. Pour a layer of castolite resin in the mold and place the items to be embedded on the resin. Finish filling the mold with resin.

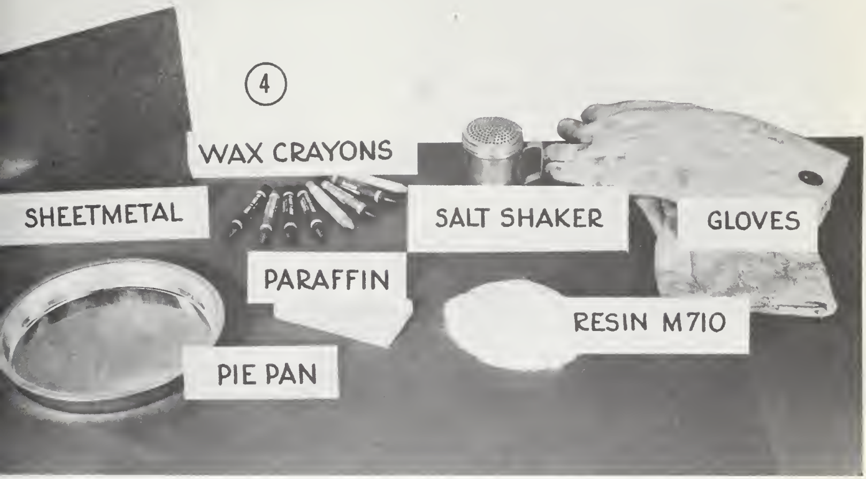
7. Place in a pre-heated oven at 150 degrees F. Leave in the oven 10 minutes for each ⅛ inch in thickness.

8. Remove from the oven and allow to cool before taking the item out of the mold.

9. If the project is one which requires machining, it may be sawed, drilled, sanded, or buffed.

The individual needs and desires will determine the item to be embedded. For the science pupil, the ideal item may be preserving

Foam plastic being used for display purposes.



Items for making a cookie tray from urethane foam plastic.

butterflies; for the botany pupil, preserving a leaf; for the coin collector, a coin; or a stamp for the stamp collector. There may be as many different projects as individuals working.

Making the mold may be a simple process or it may be one that will require much time in design and construction. This, again, will depend on individual taste. For example, a mold for embedding stamps may be made in two or three minutes by forming a piece of aluminum foil by hand. Another might have a stamp that he would want embedded in a gear shift knob. To make the mold for the gear shift knob would require accurate measurements, good design, and good workmanship. The mold may be made of wood in half sections assembled with screws. A smooth finish is needed on the inside of the mold to assure release and for the plastic not to be disfigured.

Experiment 18:

Embedding butterflies or leaves:

1. Make a mold with aluminum foil.
2. Prepare the item to be embedded.
3. Mix castoglas resin with the

Covering a picture on wood with plastic resin.

hardener. Follow the directions of the supplier.

4. Pour the required amount of resin in the mold; place the butterfly or leaf on the resin.

5. Cover the item being embedded with resin and allow to harden at room temperature 30 to 40 minutes.

6. Take the plastic out of the mold, and then a machine is needed. The plastic may be sawed, drilled, sanded, and buffed.

Experiment 19

Using water-mixed molding clay to form a plastic sculpture design:

1. Smooth the moist molding clay by rolling it out with a tool, such as a rolling pin.

2. Design grooves in the molding clay; build a lining of waxed wood or paper strips. The wax serves as a mold release.

3. Mix the desired colors of polyester resins, or any clear liquid plastic, that is cured by a catalyst. Remember the amount of coloring will determine whether the plastic is transparent, translucent, or opaque. The smaller amount will produce a transparent effect, while a larger amount of color will produce more opaque plastic.

4. Mix the catalyst thoroughly into the mixture of polyester resin

and coloring. Just a little larger portion of catalyst is needed, due to the moist clay.

5. Pour the colors into the grooves of the molding clay. This selection of colors should be well balanced, testing the artist's ability.

6. Allow the resin to cure in the grooves and then fill the entire mold with a clear mixture of resin and catalyst. The strips of waxed wood or waxed paper are used to hold this clear resin in the form.

7. Mix clear resin and catalyst and pour in a mold, such as a polyethylene egg tray. These trays form a half sphere.

8. After the plastics in the clay mold and in the egg tray have cured, take them out. Glue the half spheres on the clay-molded plastic, with the clear resin mix.

Experiment 20:

Using plastic resin for dip molding to insulate pliers against electric shock:

1. Select a container (such as a glass jar) large enough for the handles of the pliers.

2. Fill the container with resin and mix with the desired color pigment. Vinyl plastisol resin, a milk-white liquid with a paint-like texture, is good for dip molding. It becomes clear when heated. If sealed airtight when not in use, plastisol has a shelf life of one year.

3. Fasten suspension wire to the pliers. This wire can be made

Removing the hot pliers from the plastic resin in dip molding.

from woven clothesline wire. The wire is bent so it will hook on a rack in the oven.

4. Heat the pliers in the oven for 30 minutes at 450 degrees F.

5. Remove the hot pliers from the oven and dip the handles into the plastic. Allow the handles to stay in the plastic for 20 seconds. Warning: These pliers are hot. Asbestos gloves or a pair of tongs should be used to remove the hot pliers from the oven.

6. Withdraw the pliers from the plastic slowly at the rate of 1 to 2 seconds per inch.

7. Hold the pliers above the container until the dripping stops.

8. Suspend the pliers back in the preheated oven 300 degrees F. and heat for 5 to 10 minutes. Care must be taken not to allow the plastic or the pliers to touch any object as the pliers are placed in the oven.

9. Remove the pliers from the oven and cool by running cold water over them. If a thicker coat of plastic is wanted, repeat the heating and dipping steps.

17 FIBER GLASS

Fiber glass is a material made from glass fibers and plastic resins. The glass fibers are produced as continuous strands, yarns, roving, chopped strands, reinforcing mats, surfacing mats, and woven. The resin plastics are thermosetting and thermoplastic.

Polyester resin, a thermosetting type, accounts for approximately 85 percent of resin material used in fiber glass laminates. Other thermosetting resins used are: epoxies, phenolics, silicones, acrylics, and polyesters modified with acrylics.

Some thermoplastic resins used with glass reinforcement are polystyrene, nylon, polycarbonates, and acetals.

Polyester resins have the simplest and most versatile production techniques, good electrical properties, good mechanical properties, and chemical resistance. They are used in such items as boats, auto bodies, furniture, and household appliances.

Epoxy resins have good adhesive properties for use in storage tanks, plastic tooling, and aircraft. The type of glass fiber and the type of resin to use in making a fiber glass project will depend on:

1. The equipment available.
2. The type project wanted, such as a boat or a place mat.
3. Strength needed.
4. Color and design.

Some of the many uses of fiber glass are for insulated tank trucks, skylighting, boats, food processing and delivery trays, vaulting poles, transformers, motors, switch gears, fishing rods, archery bows, arrows, golf carts, protective helmets, lawn furniture, fuel storage tanks, and laundry tubs.

The strength of the finished object is related to the amount of glass used. A project containing 25 percent resin and 75 percent glass is twice as strong as a project containing 25 percent glass and 75 percent resin. The arrangement of the glass to a great extent determines the strength of the material.

For example, when all the strands are laid parallel to each other, maximum strength is in one direction. This type of strength is needed in projects such as vaulting poles, fishing rods, and golf clubs.

When half the strands are laid at right angles to the other half, strength is in two directions. This type of lay-up is used in swimming pools and boats.

When the glass is arranged in a

random manner the strength is reduced but is uniform. This method is used in chairs, helmets, and electrical parts.

By varying ingredients such as filler, pigment, and the catalyst system, each resin mix can be made to vary in performance. Fiber glass items are usually made either by the lay-up or spray-up method. The lay-up method is placing the various layers of resin and fiber glass by hand; the spray-up method is using a spray that is equipped with three hoses. One hose feeds the catalyst and resin onto the mold. Another hose feeds the chopped fiber glass onto the mold, and the third hose feeds accelerator and resin. The resin comes from pressure tanks.

The lay-up method is done by applying coats of resin with a brush. After the resin has set, layers of fiber glass are placed on by hand and then saturated with resin by using a brush. The number of layers of resin and fiber glass is determined by the thickness needed. The last coat may be a gel coat of colored resin to give the desired finish.

Several preparations are made before starting a lay-up. Safety precautions are important, although, generally speaking, working with fiber glass and resin materials is safe:

- ***Safety notes.***

1. Good room ventilation is needed because resin fumes can irritate the eyes and skin.
2. The correct procedure in mixing resin is necessary because mixing the accelerator and catalyst together improperly could cause an explosion. Follow the manufacturer's recommendations carefully when mixing catalysts in the resin. As a rule, the accelerator is added to the resin at the factory. If this has not been added, be sure to mix the accelerator and the catalyst separately.
3. Gloves must be worn when working with glass fibers and resins. This is to avoid irritation.
4. Hands must be kept away from the eyes while working.
5. A mask is worn while sanding fiber glass on the machine sander.
6. The catalyst and resin should be kept away from fire at all times.
7. Cover the work station with disposable paper.
8. Wear long shop coats while working with fiber glass, because both the glass fibers and the resin can damage clothing.

- ***Getting supplies together.***

The second step is getting all supplies and materials ready. This is necessary because, after the catalyst has been added to the resin, the working time is limited before the resin jells. The percent of catalyst will determine the amount of working time. For example, if 1 percent is added, there will be more working (lay-up) time than if 2 percent is added.

The mold is to be made ready for the lay-up before mixing the resin and the catalyst. The mold

may be simple or elaborate. However, it is suggested that the beginner start either with a flat mold or make a minor repair on a boat or other item.

This entire discussion of fiber glass should be read carefully before starting to make a project or repair an item.

The shop tools used to work with fiber glass, as a rule, should be separate from those used to fabricate other plastics, because fiber glass is so hard it will dull wood and plastic cutting tools.

Metal cutting saws are recommended. However, a wood cutting, fine-tooth hand saw may be used if it is kept for fiber glass only. The metal cutting hack saw is ideal for sawing by hand if the material is small enough.

A band saw geared for slow speed and equipped with a metal cutting blade is the usual cutting tool. The circle saw may be used with a carbon grit blade. Care must be taken when sawing fiber glass on the band saw or the circle saw to feed the material slowly. Know all of the *safety rules* for using these saws and be sure each rule is followed. See the chapter on Power Saws.

Fiber glass may be sanded on the belt or disc sander if medium or coarse grit emery sandpaper is on the machine. Flint sandpaper, often used for fine sanding of acrylic plastics, will be torn off the machine if used to sand fiber glass. Know and observe all *safety rules* for machine sanding. See the chapter on Machine Sanders.

Use a wood cabinet file and then a metal file to remove coarse sanding marks. Hand sanding with fine sandpaper is then used to remove metal file marks. The buffer is used to polish the surface.

The kind of decorations is determined before starting to make a project. Often with large projects, such as boats, a color is chosen and added to the resin before adding the catalyst. Four ounces of color pigments are added to one gallon of resin for the darker shades. When lighter shades are desired, of course, a smaller amount of color pigments is added. The color pigments are mixed thoroughly with the resin to assure uniformity.

Decorating shop projects such as lamps, trays, or mats offers an opportunity to use your maximum abilities. You may design on thin fiber glass cloth, using wax crayons. This is done after you have pre-cut your material, and before starting the lay-up. Or you may select a decorative cloth to be placed in the laminate, or such items as fish flies may be used, with clear resin.

A combination of clear and colored resin will produce an attractive item. After this the lay-up is completed, with the exception of the clear gel coat, and then lines of a colored resin are streaked on the surface to form the desired design.

A place mat is a suggested project for the beginner because it requires only a flat mold, the sim-

plest to make. Yet it requires the major process as well as offering the opportunity for individual designing.

Procedure

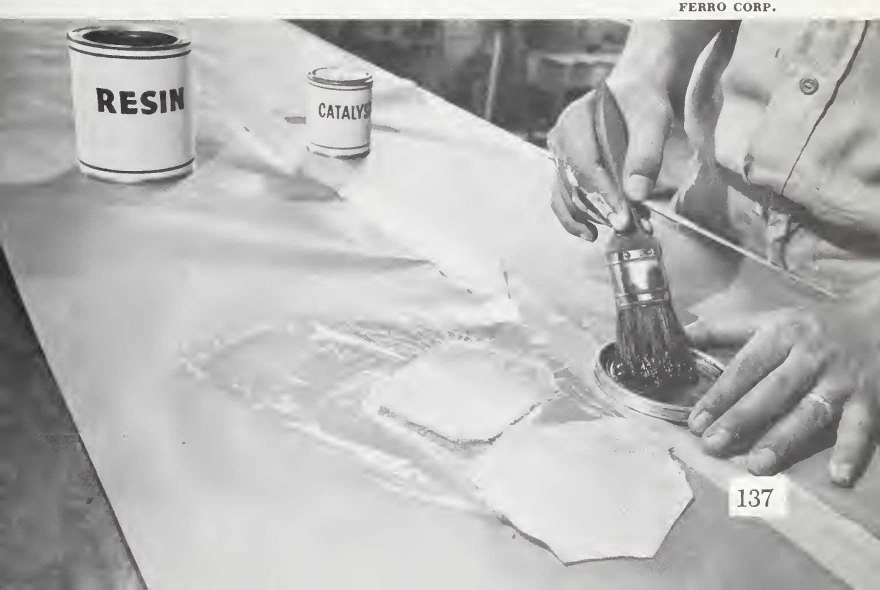
1. Cut two pieces of ¾ inch plywood and Formica-type sheets 10 × 10 inches to be used as the mold.
2. Sand the edges smooth and buff the surfaces.
3. Cut the fiber glass cloth for the lay-up 12 × 12 inches. This material may be reinforcing mat, woven mat, or continuous strand mat. If a design is to be drawn on the cloth, a close woven surface is needed.
4. Prepare for the design. This is done by first determining the design itself. If colorful cloth is to be used for the design, it is cut 12 × 12 inches. The cloth must be clean and pressed smooth. If the design is to be drawn on the fiber glass, wax crayon colors are used. If you prefer colored resin, it is colored to the desired hue.

5. Apply the mold release on the Formica-type surfaces. Silicon spray is a good mold release or parting agent. If not available, a piece of cellophane may be substituted. To assure a good surface, the cellophane must be smoothed on carefully and taped to the plywood edge.

6. Apply the gel coat. This is mixed with 2 percent catalyst. Two ounces of resin with sixteen drops of catalyst should be sufficient for both surfaces of the cellophane. NOTE: if the room temperature is lower than 76 degrees,

Saturating fiber glass mat with mixed resin.

FERRO CORP.



F. add one additional drop of catalyst.

7. Brush the gel coat onto the mold surfaces smoothly and to about the thickness of 3 or 4 sheets of paper. The coat should cure in 60 to 90 minutes.

8. Clean the brush. Acetone is good for this purpose.

9. After the gel coat has cured, sand it lightly with 6/0 sandpaper.

10. Mix from 6 to 8 ounces of resin with 30 to 40 drops of catalyst. This should be sufficient to complete the project.

11. Brush a layer of resin on one of the gel-coated surfaces. If colorful cotton cloth is to be used for decoration, it is now placed on the resined surface and saturated with resin, smoothly and with all air pockets brushed out. If a design has been drawn on the fiber glass mat for the decoration, this mat is placed on the mold with the design next to the gel coat. Only one of these decoration methods is to be used at a time.

12. The number of layers of glass fibers and resin is determined by the desired thickness; one or two will be sufficient. Each layer is saturated with resin and the air pockets brushed out.

13. Apply a coat of resin on the gel coated surface at the top section of the mold. Place it on the laminate. Move this around to

Fiber glass mat in a flat mold with weight, and a mat that was made in the mold.

Sawing a fiber glass mat on the band saw.

assure pressing out air pockets, and place an 8 to 10 pound weight on the top section of the mold.

14. Allow the mold to set until the resin has cured. The time necessary for curing will be determined by the amount of catalyst used, the thickness of the laminate, and the temperature of the room. It usually runs from 2 to 3 hours.

15. Clean the brush thoroughly.

16. After the resin has cured, remove the laminate fiber glass from the mold. Care must be taken not to damage the mold or the project while removing it. A case knife or a rounded end putty knife may be used to loosen the item. Usually the mold will release after a knife has been pushed around the edges. If pressure is needed, take care not to damage the mold or the project.

17. Cut off the edges, using a slow-speed band saw with a metal cutting blade. The project may first be marked for sawing with a scratch awl or shop dividers. Take care to observe all *safety rules* while using the band saw.

18. Sand the saw marks out with a disc or belt sander, using medium grit sandpaper. Observe all *safety rules* while using the machine sander.

19. Place the project in a wood vise and file out the machine sanding marks by first using a cabinet file and then a metal file. Take care to protect the surfaces, as with paper toweling, when the project is in the vise.

20. Sand the file marks out, using fine 4/0 to 6/0 sandpaper.

21. Remove the project from the vise and buff the edge, using buffing compound and wax on the cutting wheel and polish on the polishing wheel. Take care not to

Fiber glass tray and mold—female section made of wood and Formica. Male section made of rubber.

get the corner caught in the buffing wheel, by starting in the center of each edge and buffing down to the corner. If the corner is placed into the buffer first, the project is apt to get caught and thrown, making it dangerous for the operator as well as others. Observe all *safety rules* while using the buffing machine.

• *Mold for the fiber glass tray.*

Procedure

1. Make a pattern in the shape of a tear drop, with the over-all dimensions 1 × 5 × 8 inches.
2. Transfer the pattern to a piece of close grain wood, such as maple, 1 × 9 × 12 inches.
3. Drill a ⅜ inch hole through the wood on the inside of the pattern.
4. Set the jig saw table at a 5 degree angle. This is needed for mold release.
5. Assemble the wood on the jig saw and cut out the pattern.
6. File and sand the inside edges smooth.
7. Apply three coats of resin on the inside edge, allowing drying time between each coat.
8. Fasten this part of the mold onto a piece of plywood and Formica. The larger cut-out portion is to be the top, thus giving the 5 degree angle for mold release. This completes the female part of the mold.
9. Cut the pattern down ¼ inch and transfer it on to a piece of rubber, 1 or 1½ inches in thickness, to make the male part of the mold.
10. Cut this pattern out with the band saw. The band saw table is set at a 5 degree angle. Raw rubber may be secured in short pieces from tire recapping shops. Some of this rubber is approximately ½ inch in thickness. To get rubber for a mold 1 inch thicker, two pieces are adhered together and heated in a pre-heated oven of 300 degrees F. for 1½ hours. Air bubbles may be prevented by heating the rubber between pieces of plywood, using C clamps.

• *Using the tear-drop mold.*

Procedure

1. Place cellophane in the bottom of the female mold.
2. Mix 4 drops of catalyst in 1 ounce of polyester resin and stir. Usually the accelerator has been

added at the factory. However, it is advisable to check before using the resin.

3. Brush the resin on the cellophane evenly and allow to cure for 1 hour.
4. Cut a piece of glass mat, or woven material, 7 × 10 inches, and place in the mold.
5. Mix 3 ounces of polyester resin and 8 to 10 drops of catalyst.
6. Saturate the glass fibers with the resin by brushing it into the fibers.
7. Place the second piece of glass fiber in the mold and saturate with resin.
8. Place a colorful piece of cloth in the mold and saturate with resin.
9. Place a piece of cellophane on the rubber portion of the mold; then place the rubber down in the female mold.
10. Place a piece of plywood on the rubber and clamp it with enough pressure to force the rubber into all cavities.
11. Permit the resin to cure. Curing time is from 3 to 5 hours.
12. Remove from the mold and trim the edges by using a metal cutting band saw. The material will dull a wood cutting saw.
13. Sand the edges on the belt sander.
14. File the edges with a metal cutting file to remove the streaks made by the belt sander.
15. Sand the edges by hand, using fine 6/0 sandpaper to remove file marks.
16. Buff the edges.

Making fiber glass projects using *cardboard for forms* is a technique practiced in many instances. For example, if a cylinder is needed, it is made as follows:

Procedure

1. Secure a paper cylinder the desired size. This may be a salt container with the label paper taken off.
2. Spray the paper cylinder with a mold release used as a parting agent.
3. Cut glass fiber cloth the proper size to fit around the cylinder.
4. Mix resin and catalyst sufficient to cover.
5. Brush the resin on the cylinder and allow it to set for 1 hour.
6. Mix enough resin and catalyst to finish the project; 3 or 4 ounces should be sufficient for a cylinder the size of a 1 pound salt container.
7. Place the pre-cut glass fiber cloth around the cylinder and saturate it thoroughly with resin. This is brushed until all air bubbles are out.
8. Allow the resin to cure from 3 to 5 hours.
9. Sand the resin surface smooth and brush a gel coat on the cylinder; allow to cure for 3 to 5 hours.
10. Cut the end true, using a metal cutting band saw.
11. Tear the paper cylinder out of the inside. If the end is to be smooth, machine sand, file, hand sand, and buff.

Other projects are made in a

Mold made on the lathe for a fiber glass bowl.

similar manner by making a model from cardboard paper and brushing or spraying on the resin and glass fibers.

- ***Making curved molds.***

A good way to make a mold is on the lathe, if the project is designed as a curve, such as bowls or rounded trays. This mold is turned out of close-grain hardwood.

Procedure

1. Select wood which is free of flaws. The size is determined by the size of the project. The dimension of the female mold should be 3 inches larger than the project to be made. This will leave a 1½ inch rim for strength. A thin rim, 1 inch and under, is often broken by handling or use.
2. Mark the disc with dividers and saw it out, using the band saw. This marking is done on the back face of the wood. The center mark made by the dividers is used to place the faceplate in the center of the wood.
3. Fasten the faceplate on with screws. First mark and drill holes the correct size. The size of the screws will determine the size of the holes. Take care to select screws that will assure the faceplate's being fastened onto the wood securely. Also take care to select screws that are not too long. Screws which are too long will be cut when turning out the mold. This would damage both the mold and the turning tool.
4. Fasten the faceplate on the lathe and turn the mold to the shape and size. Observe all safety rules for turning.
5. Sand the inside of the mold, using 2/0 sandpaper followed by 4/0 and 6/0. Sand thoroughly, be-

cause any roughness will disfigure the project.

6. Remove the female section from the faceplate and assemble the wood for the male section, following the same procedure.

7. Turn the male portion of the mold out $\frac{1}{4}$ inch smaller than the female portion. This will mold a project $\frac{1}{8}$ inch in thickness. Be sure to turn the male mold the same shape as the female mold.

8. Sand the wood smooth, using 2/0 sandpaper, then follow up with 4/0 and 6/0.

9. Remove the mold from the lathe and apply a coat of polyester resin, properly catalyzed, to both parts. Permit to cure for 24 hours.

10. Sand the resin coat lightly and apply the second coat of properly mixed resin. Permit to cure for 24 hours and again sand lightly.

Procedure for using the mold

1. Apply a mold release on both parts.

2. Cut the fiber glass cloth 2 inches larger than the inside of the female mold.

3. Mix a small amount of polyester resin and coloring.

4. Mix the colored resin and catalyst.

5. Apply a coat of mixed resin on both parts of the mold and allow to cure until it becomes tacky.

6. Mix sufficient resin and coloring to complete the project.

7. Mix the colored resin and catalyst.

8. Place the fiber glass cloth in the mold and saturate with the resin. Apply the second layer of cloth and again saturate it with resin.

9. Place the male section of the mold on the lay-up; then place a 10 to 12 pound weight on the mold or clamp with spring clamps. Allow to cure for 5 hours or more.

10. Remove the project from the mold and saw the edge off with a metal cutting band saw. Observe all *safety rules* while using the band saw.

11. Sand the edges smooth on the disc sander, using coarse sandpaper.

Roughening a damaged surface area with a portable drill and a ball-shaped burr attachment.

FERRO CORP.

Applying a gel coat of resin mix to the scratched area.

FERRO CORP.

Trimming the patch flush after partial cure, using a sharp chisel.

12. File the edge, using a cabinet file and then a metal file.
13. Hand sand the edges, using 6/0 sandpaper. Then buff.

Covering the patched area with cellophane.

FERRO CORP.

• *Repairing fiber glass items.*

Fiber glass items may often be repaired economically and effectively. The repair may be only a scratch on the finish or it may be a hole in the fiber glass. A scratch may have damaged just the gel coat and colored finish, or it may be deep enough to have penetrated into the glass reinforced area.

Procedure for Repairing Scratches

1. Clean the scratch and the area around the scratch.
2. Roughen the damaged area and feather the edge surrounding the scratch. This may be done with a power drill and burr attachment or by hand sanding.
3. Mix the gel coat of resin. The color must match the color of the fiberglas item.
4. Mix a small amount of the

Place a small amount of resin after trimming and cover the patch with cellophane.

FERRO CORP.

Apply the cellophane over the repair for the cure.

gel coat and a drop of catalyst.

5. Fill the area to be repaired with the resin mix, to 1/16 inch above the original surface.

6. Place a piece of cellophane over the patch and allow to cure for 15 minutes.

7. Remove the cellophane and trim the surface flush, using a sharp chisel or a razor blade.

8. Place a small amount of gel on the patch and spread it around the edges smoothly.

9. Replace the cellophane on the patch and allow to cure from 2 to 5 hours.

10. Sand the patch area with 1/0 sandpaper and buff with a portable buffer or finish by using rubbing compounds.

Procedure for repairing holes and tears

There may be a hole or tear in any fiber glass item, such as a lamp, a chair, a boat, or a storage tank.

1. Remove all damaged material. This will make the hole

Using an electric saber saw to cut out all damaged areas before starting a patch.

FERRO CORP.

Using a power drill and disc sander to feather the edge of a hole to be repaired.

FERRO CORP.

Preparing the outside of an area being patched using a drill with a disc sander to feather the edge.

larger; however, it is important. Cut with a sabre saw or a key hole saw. As said, metal cutting blades are best for cutting fiber glass.

2. Rough-sand the area around the inside of the hole, using 80 grit sandpaper.

3. Sand a 2 inch bevel all around the hole, using a disc sander in a portable drill. This is known as feathering the edge.

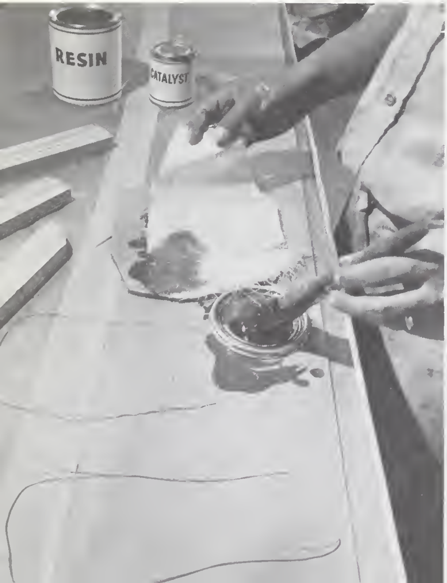
4. Tape a piece of cellophane on cardboard large enough to cover the hole. Then tape this assembly on the outside of the boat, with the cellophane facing toward the inside.

5. Cut pieces of fiber glass cloth and mat 2 inches larger than the hole. The thickness of the fiber glass in the item being repaired will determine the number of pieces of cloth needed.

6. Mix the resin and catalyst. From 2 to 4 percent catalyst is

Preparing the patch of fiber glass and resin mix.

FERRO CORP.



Applying the mixed resin on the area being patched.

FERRO CORP.

Pressing air bubbles out of the fiber glass patch.

used, depending on the working time needed and the temperature. The more catalyst that is added the less working time is required before the resin will jell. A smaller amount of catalyst will require a longer curing time. The amount of resin mixed will be determined by the amount of fiber glass cloth and mat.

7. Place a piece of cellophane about 2 inches larger than the fiber glass cloth, on the work table. Place the cloth on the cellophane and saturate the cloth thoroughly with the resin mix. Then place the fiber glass mat on the saturated cloth and saturate this mat with the resin mix. If more than two pieces of cloth and mat are used, be sure that the cloth is the first piece placed on the "sandwich."

8. Place this sandwich over the hole *from the inside,* with the cloth on the outside. Squeeze from the center to the edges to remove all air bubbles. The air bubbles would show white. Allow the patch to cure completely.

9. Remove the cardboard from the outside of the hole and bevel the edge approximately 2 inches using a portable drill and a disc sander.

10. Cover the area around the beveled surface with tape to protect the undamaged surface.

11. Cut a piece of fiber glass mat 1 inch larger than the hole; then cut fiber glass cloth large enough to cover the beveled area. The thickness needed will determine the layers of fiber glass cloth needed.

12. Mix the resin and catalyst as in step 6 and brush a layer of resin over the patch and beveled edge.

13. Place the pre-cut mat over

the hole and saturate it with the mixed resin. Then place the fiber glass cloth over the patch and saturate the cloth with the resin mix. Secure with masking tape as shown. Use enough layers of cloth to build up the patch above the surface of the item being repaired.

14. Starting from the center, apply cellophane and work out all air bubbles. A knife blade may be used.

15. Allow the patch to cure until it becomes rubbery. This will require 15 to 20 minutes. Using a sharp knife, cut away all extra material and allow to cure completely.

16. After the patch has cured, sand the area with rough sandpaper. This may be done by hand or by using a portable drill and a disc sander.

17. Mix the gel coat, using a catalyst and the desired coloring. Brush or spray this gel over the patch area. Be sure it penetrates all cavities and scratches evenly.

18. Cover the gel coat with cellophane and press out air bubbles. Leave the cellophane until the coat has completely cured.

19. Remove the cellophane, and hand sand the patch first with 2/0 sandpaper and then with 6/0. Use a sandpaper block.

20. Polish the finish with buffing compound and wax, either using a portable buffer or by hand.

There will be some difference in color for some time. However, if care has been taken to do each step well, the patch will not be noticeable after a few days.

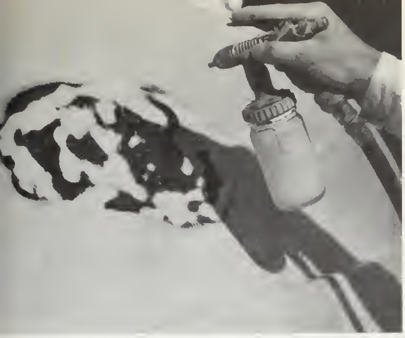
- ***Covering a wood boat with fiber glass.***

Any boat that is reasonably sound may be covered with fiber glass. This will make it leakproof

Sanding the patched area, using a portable drill and disc sander.

Showing supplies and method of mixing a gel coat.

FERRO CORP.



Using a spray device to apply mixed resin on a fiber glass lay-up.

FERRO CORP.

Pressing the air pockets out of a fiber glass patch.

and add strength. The hull may appear to be strong even when an inspection shows corroded fasteners. Therefore, before deciding to cover the hull, make sure all damaged parts can be repaired.

It is not advisable to cover a hull made of cherry or yellow pine. The boat should be one of soft grain and free of pitch.

Procedure

1. Select good material, making sure the glass fibers are free of oil.

2. Clean out all of the joints of putty, seam filler, or caulking; fill all seams, cracks, and screw holes with a non-oil base putty.

3. Remove all accessories.

4. Remove all paints, varnishes, and oil-soaked parts. A solution of ¼ pound of lye to 6 quarts of water may be used to remove the oil. The paints and varnishes are removed by scraping and sanding. Paint or varnish removers are not to be used. The sander should have coarse grit paper because it will produce a roughened surface which is a good base for the resin. Fine sandpaper will fill up quickly with paint or varnish.

5. Make a pattern for each section and cut the fiber glass cloth. This pattern should be about 4 inches larger than the boat section. Cut out all the sections that are needed and roll them up on a paper drum. The number of layers to use will be determined by the size of the boat and the strength desired. On small boats one layer of fiberglas cloth is sufficient. A boat 18 feet long or longer should

Using a sanding block and 600 grit sandpaper to sand the patched area.

FERRO CORP.

Buffing the surface of a railing after sanding a gel coat.

have two or more layers of fiberglas. A boat with heavy planks will require a thicker coat of fibers and resin because the boat will expand more in heat and shrink more in cool weather than a thin boat.

6. Mix only 1 quart of resin, following the directions of the supplier. The resin will jell before it is used if too much is mixed at a time.

Apply the first coat of resin on the boat with a brush or a roller. This coat should be heavy, brushed or rolled in every direction.

7. Allow the resin to cure for about 20 minutes at 70 or 72 degrees F. This should be sufficient for the resin to start curing. When the coat is tacky, it is ready for application of the fiber glass.

8. Unrolling small portions of fiber glass at a time and press it in the resin with the hand. It must be smooth and even. Use gloves. If two or more layers are used, add resin between the layers.

9. Apply three coats of resin about 20 minutes apart, brushing or rolling each coat on evenly. The color is added to the last coat before mixing the catalyst in the resin. The boat can be placed in the water in 5 to 8 hours after the last coat has been applied.

• ***Making fiber glass panels for a room divider.***

Procedure for Making the Mold

1. Using four pieces of 1 x 2 x 17 inch hardwood, saw a groove ⅛ inch deep ½ inch from one edge of each of the pieces.

2. Saw the ends of the wood to make 45 degree mitre joints.

3. Sand the inside and top edges of the wood. Buff the sanded surfaces so the mold release will be more effective.

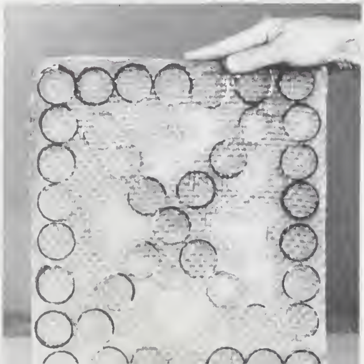
4. Assemble a piece of 15¼ x 15¼ inch plate glass into the sawed grooves of the wood.

5. Fasten the mitre joints by using wood glue and six No. 4 finishing nails. Allow the glue joint to set for 24 hours.

Procedure for Making the Panel

1. Spray the inside of the mold with mold release, covering all of the surface.

Fiber glass panel section.



2. Place a piece of 15 x 15 inch fiber glass on the inside of the mold.

3. Saw ½ inch thick rings from a 1½ inch diameter paper cylinder. These rings give the panel added thickness plus design. Designs may also be created by using bottle tops or wood chips instead of rings.

4. Measure 5 ounces of plastic resin into a paper cup. Stir in 2 or 3 drops of amber dye.

5. Stir 25 to 30 drops of catalyst into the resin. The temperature of the room and the time needed to apply the resin to the fiber glass determines the amount of catalyst used. The more catalyst used and the higher the temperature, the quicker the resin has to be applied.

6. Using a 1½ inch paint brush, saturate the fiber glass with the plastic resin. Saturate all of the material and brush out all air bubbles. Clean the brush with plastic resin thinner.

7. Place the paper rings on the saturated fiber glass, forming the desired design. Then place a piece of 15 x 15 inch plate glass on the paper rings and a 4 or 5 pound weight on the plate glass. Allow to set for 24 hours.

8. Remove the fiber glass from the mold. A screwdriver may be *carefully* used to press the fiber glass loose.

9. Clean the mold and spray again with mold release.

10. Place a second piece of 15 x 15 inch fiber glass in the mold. Repeat the same process of mixing the plastic resin and saturating the fiber glass.

11. Put the first piece of fiber glass made on this saturated fiber glass with the paper rings on the inside.

12. Again, place the plate glass on the fiber glass and weight it down. Allow this to set for 24 hours.

13. Remove the fiber glass from the mold as before.

14. Mark the edges and saw the panel, using a metal cutting band saw.

15. Follow the same procedure to make the desired number of 14 inch panels. Once the needed number of panels are made, strips of wood or plastic are used to make the framing. This is done by cutting dadoes into the strips. WARNING: Cut dadoes on one side only on the strips to be used as the outer edges. The other strips should have dados on both sides.

Questions on Fiber Glass

1. What materials are used to make fiber glass?

2. In what forms may glass fibers be purchased?

3. What kind of resins are usually used to make fiber glass?

4. What is an advantage of an epoxy resin?

5. Which is the strongest: a project with 25 per cent resin and 75 percent glass fibers or a project with 25 percent glass fibers and 75 percent resin?

6. When should all the fiber strands be parallel to each other?

18 LAMINATING CLEAR PLASTIC*

Laminating pieces of clear plastic is as fascinating as any of the processes in plastics. Upon the proper application of heat and pressure, the pieces are joined in a bond that cannot be seen and which is as solid as the stock itself. The applications of this process are limitless. To mention a few, pictures can be imbedded permanently, bracelets can be made with interesting designs, as can box covers, desk ornaments, pins, and other objects for which plastics are suited. Various colors can be joined and turned on a lathe for projects such as gavels, paperweights, and chessmen. Interesting effects can be secured by laminating several thicknesses of Plexiglas or Lucite together with designs incorporated between the several layers.

Laminated bracelet. Dark red Plexiglas or Lucite strips welded together, with copper wire and green cloth "shapes" between, for ornament.

Materials to be laminated should be relatively flat and unaffected by heat up to 400 degrees F. Wire, metal foil, metallic dust, fabric, and wire mesh are examples of materials that are particularly well suited both from the standpoint of design and adaptability to the process. The plastic to be laminated may be of any thickness or color. It must be clean and free from oil and wax.

There are several methods of laminating which may be used successfully, three of which are described here. These will produce satisfactory results for a wide variety of projects.

The simplest method consists of placing the pieces to be joined on a flat surface that can be heated to approximately 400 degrees F., heating them until they become very pliable, then placing

*This information on lamination contributed by Prof. R. A. La Bounty, Head of Industrial Arts Department, Eastern Michigan University, Ypsilanti, Michigan.

Further use of paper cloth emblems laminated between a clear piece of Plexiglas or Lucite and an opaque piece for the background.

the object to be imbedded in place, and carefully pressing the assembly together. This method is most satisfactory for small objects.

The second method parallels the first, except the pieces are heated on separate surfaces that can be clamped together when the proper temperature is reached. Pressure must be applied evenly to avoid air pockets being left in sections of the pieces of stock. A vise or hand clamps may be used to apply the pressure. The stock is left under pressure until cool enough to handle with the bare hands.

The third method of laminating consists of using a press into which the plastic pieces and design being imbedded can be placed, and the whole assembly heated while under pressure. When the material is centered in the press, the press is tightened finger tight, plus one turn. The assembly is then placed in an oven and heated to a temperature of 400 degrees F. for a period of fifteen minutes. The press is then removed and

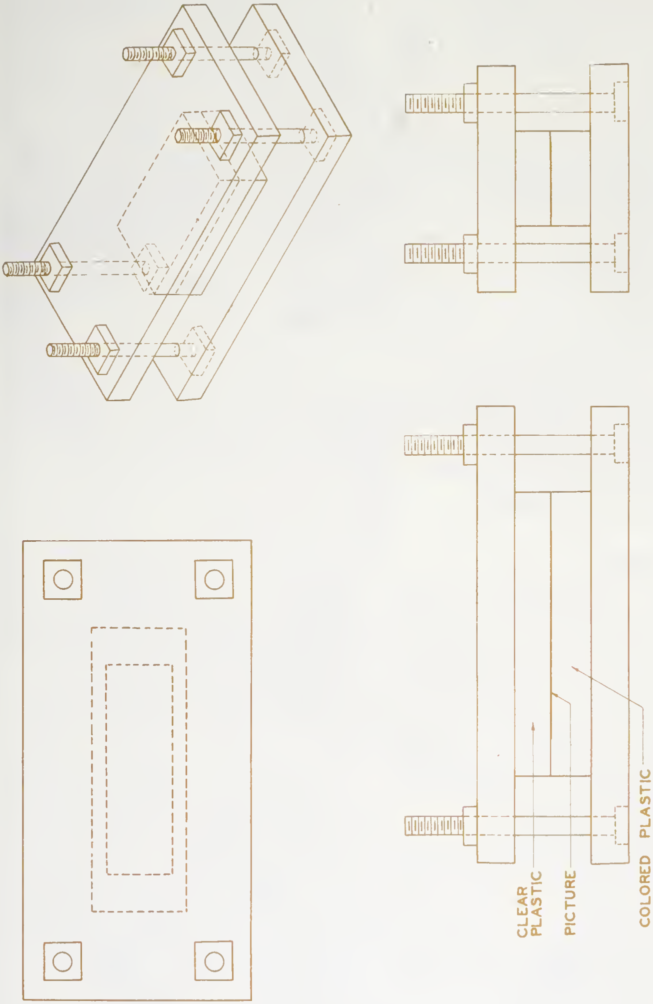
Clear Plexiglas or Lucite laminated to opaque, with many-colored fish fly in between and gold key chain attached. The effect in color is highly ornamental. It is not apparent that a fish fly is used unless the observer looks closely.

Cuff links made with fish flies.

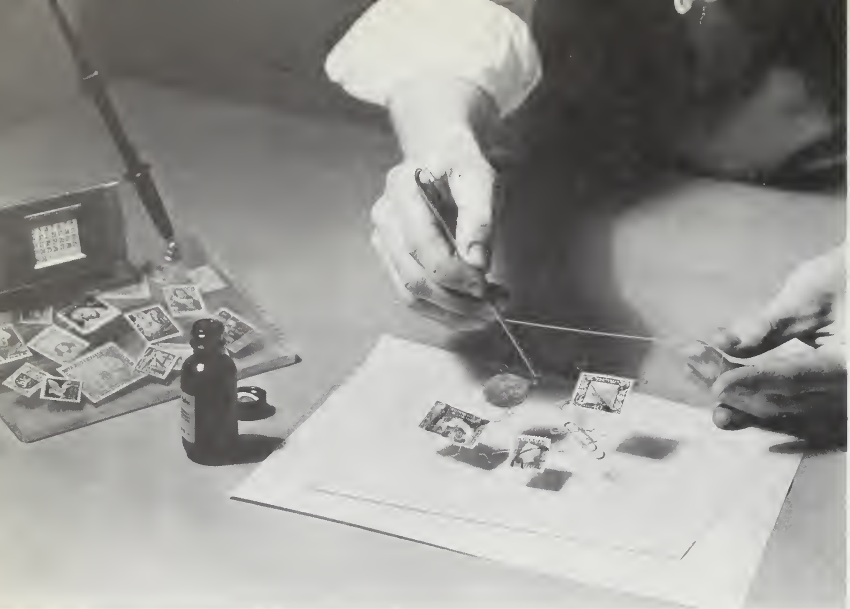
tightened again. The amount of pressure to apply depends somewhat upon the thickness of the stock and the type of material being laminated. In general, one to two complete turns will suffice. The edges of the stock in the press will bulge under pressure. The slight bulge desired for adequate bonding will serve as a guide for the amount of pressure to apply.

After the increased pressure is applied the whole assembly is again heated for an additional fifteen minutes at the same temperature as before. At the end of this heating period, the stock and press may be cooled in water. The stock may then be treated as one piece. It can be formed, dyed, cut, polished, or cemented in the same manner as other Plexiglas.

Child's photo laminated between two pieces of clear Lucite or Plexiglas, mounted on black plastic base.



Laminating press. Use wing nuts for quicker handling.



WARNER ELECTRIC

Preparation for laminating items in plastic.

A satisfactory press may be made by welding three ½ x 2 inch machine bolts to a piece of ⅜ x 4 x 8 inch steel plate, and drilling ½ inch holes through a second plate. Such a press can be assembled quickly without disturbing the pieces to be laminated. It is desirable, but not necessary, to have the surfaces of the plates ground and plated. The resultant smooth surfaces minimize the buffing and polishing required on the laminated plastic.

Press Procedure for Laminating Items Such as Watch Parts

1. Set the thermostat at 310 degrees F. The pilot light will go off when the press has heated to 310 degrees.
2. Select the plastic, Lucite or Plexiglas, the same thickness as items to be laminated.
3. Assemble sandwich:

- Place two blotters on clean table.
- Place one polished plate on the blotters.
- Place one plastic sheet on the polished plate.
- Place object to be laminated on plastic.
- Place second piece of plastic on objects to be laminated.
- Place second polished plate on plastic.
- Place two blotters on polished plate.

4. Place sandwich in laminating press and apply 2 pounds of pressure.

5. Allow to heat for 5 minutes.

6. Apply 25 pounds of pressure every 2 minutes until 200 pounds is reached.

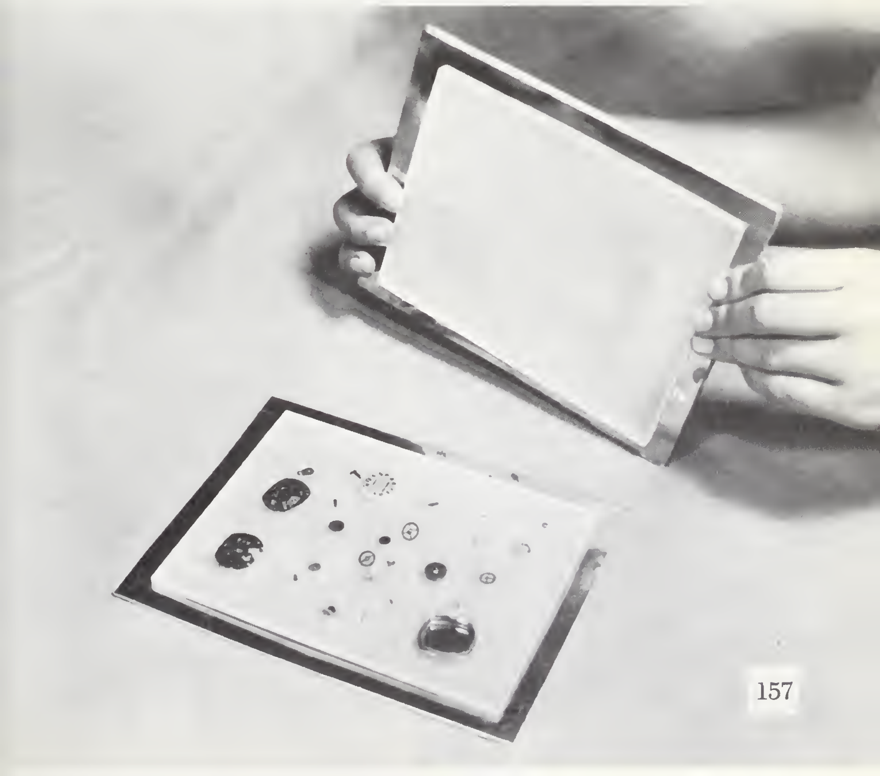
7. Allow to heat for 5 minutes.

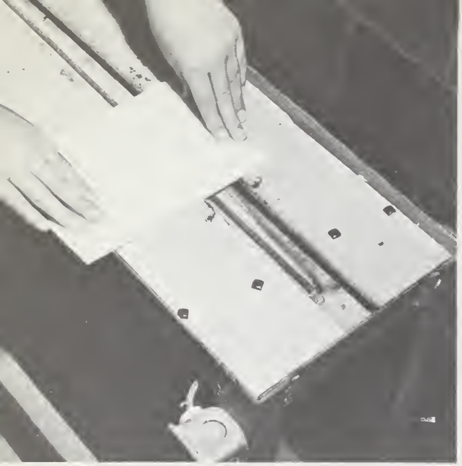
8. Set heating gauge at 50 degrees F. and run cold water through the press. When the pilot light goes on, the sandwich is ready to be taken out.

Do not be alarmed if the edges

Plastic jewelry box, with the parts of a watch laminated into the top.

Sandwich of blotters, metal plates, plastic, and watch parts laminated for jewelry boxtop.





Use of strip heater for 90° bend.

of the upper and lower platens do not square up exactly or if they are not parallel when they are in an open position. The lower platen, as it closes, will adjust itself parallel to the upper platen as pressure is shown on the gauge.

There is a normal pressure drop during the period of laminating due to the extrusion of the heated plastic. This is from 20 to 65 pounds. However, if as much as 100 pounds drop occurs, there is something wrong with the adjustments on the press. To correct, first turn the pressure valve knob hard to the right and pump the press up to 300 pounds. If the pressure continues to drop, lay the press on its side and open the pressure control arm eight to ten full strokes. Repeat this step several times if, after standing the press upright, it still fails to hold pressure.

Sometimes the two hex coupling nuts connecting the hydraulic line to the pressure gauge get loose. This will cause pressure loss. To correct, tip the press on its back and tighten the coupling nuts.

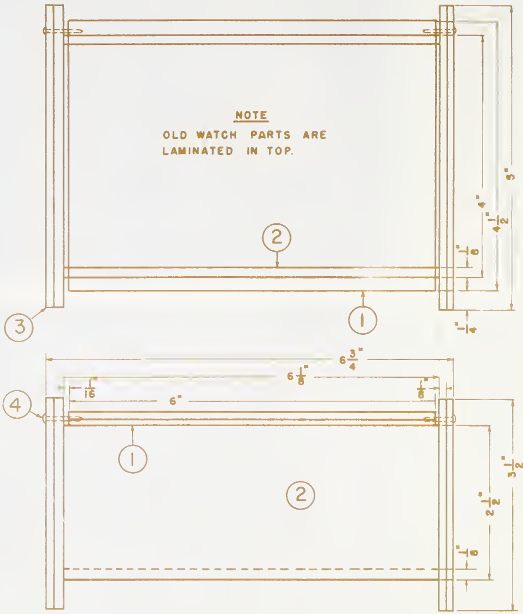
Plastic bent after strip heater operation.

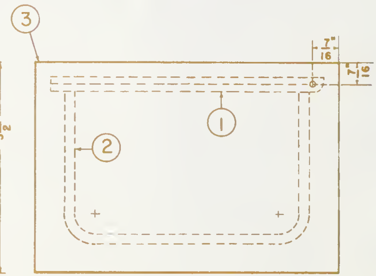
Press Procedure for Laminating Cards, Photographs, Stamps, or Clippings

1. Set the press thermostat at 310 degrees F. The pilot light will glow until the correct temperature is reached.
2. Prepare clear vinylite sheets ½ inch larger than the item to be laminated.
3. Make sandwich as described above, using vinylite instead of Plexiglas or Lucite.
4. Place sandwich in laminating press and apply 2 pounds of pressure.
5. Allow to heat 1 minute and apply 60 pounds of pressure.
6. Set the press thermostat at 50 degrees and turn the water through the press. When the light goes on, the sandwich is ready to come out.

PARTS LIST

PART NO.	NAME OF PART	NUMBER NEEDED.	MATERIAL	SIZE
1.	TOP	2	CLEAR PLASTIC	$\frac{1}{8}'' \times 4\frac{1}{2}'' \times 6''$
2.	BOTTOM & SIDES	1	WHITE PLASTIC	$\frac{1}{8}'' \times 6\frac{1}{8}'' \times 8''$
3.	ENDS	4	2 CLEAR PLASTIC 2 WHITE PLASTIC	$\frac{1}{8}'' \times 5'' \times 3\frac{1}{2}''$
4.	HINGE PINS	2	BRASS	$\frac{1}{16}''D \times \frac{5}{8}''$





WARNING: The first water that comes through the press will be hot or even steam. Start the water through slowly; keep hands away from the end of the water hose, for *safety*.

To laminate more than one sandwich of photographs or cards at a time, the performance is the same except one cushion blotter is placed between each sandwich. The greater over-all thickness requires a correspondingly longer period for pre-heating to assure proper laminating temperature throughout the entire thickness of the assembly. For example, the pre-heating time for one sandwich is 1 minute and final pressure time is 2 minutes. If four sandwiches are being laminated at one time, 5 minutes pre-heating time and 3 minutes of final pressure time are needed.

- ***Proper heating.***

The time element for pre-heating and heating under final pressure is also worked out correspondingly when laminating watch parts or other items in thicker plastics. It is necessary that all of the plastic be heated to the proper temperature, 310 degrees F., to assure a complete seal around each item. If you fail to do this, there will be air pockets around the item being laminated. If the proper heating time is given and the correct pressure applied, the plastic will flow into all cavities, leaving no air pockets.

- ***Preventing fogginess.***

Sometimes there is a foggy or

Placing a sandwich in the laminating press.

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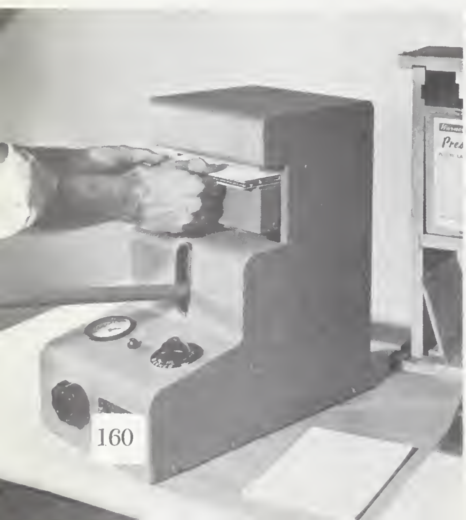

Preparation for laminating a picture.

milky appearance over or around the paper items. This defect may show up at the time the lamination is removed from the press, or several hours afterward. This foggy or milky appearance is due to moisture in the photograph or other paper item. This moisture is removed before laminating by placing the item between the polished metal plates and a blotter and drying them in the laminating press while the press is heating to the proper temperature. Do not apply pressure on the plates, and don't allow the heat to get over 200 degrees F. One to two minutes drying time will remove all of the moisture.

Proper amount of *pressure* and *correct timing* are major elements to assure good results in laminating.

The *thickness* of the item to be laminated should be less than one-half the thickness of the plastic. If a triple-weight photo paper has been used, an extra sheet of vinylite is added. To laminate bulk items, each piece of acrylic plastic is at least the thickness of the item.

A good suggestion would be to practice laminating a card or picture, of no value, in order to develop assurance and skills.

• ***Tack welding design parts.***

After successful experience in laminating cards or pictures in clear vinylite sheets, you are ready to laminate a design of paper items between two pieces of clear acrylic plastic. To place the design of the cutouts or stamps, *tack welding* is needed because of static electricity generated by the

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Pen and calendar base, with items laminated in the plastic.

Assortment of plastic items laminated in the press.

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plastic. To tack weld, place a small amount of thick plastic solvent on the stock where each part of the design is to be placed, using a tooth pick or similar stick. The weld needs to be only strong enough to keep static electricity from pulling the items out of place. Too much solvent will discolor the stamps. To make thick plastic solvent, dissolve clear plastic chips in ethylene dichloride.

After the design is placed on the stock correctly, the sandwich is completed and laminated with the procedure described above.

- ***Plastic glue designs.***

Another interesting process is making decorative designs with plastic glue, and laminating between two pieces of plastic. The colored glue is placed on only one piece of the plastic. Possibilities are spider web, rainbow, or wave designs. Allow to dry before assembling the sandwich to prevent the glue from running into other parts of the design, thus disfiguring it.

This project offers a good opportunity for color arrangements and combinations.

Laminated candle holders.

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Procedure for Making a Laminated Jewelry Box

1. Lay out and cut out two pieces of clear plastic for the top.
2. Turn on the laminating press and set the thermometer at 310 degrees. The pilot light will go off at this temperature.
3. Make a sandwich of blotters, metal plates, plastic, and watch parts, using procedures already described.
4. Place the sandwich in the press and laminate the watch parts into the plastic by procedures described.
5. Take the sandwich out of the press and machine sand the edges. These edges will bulge out from pressure during heating. Machine sand the edges true.
6. Hand sand the edges and buff to a high polish.
7. Lay out and cut the white plastic for the sides and bottom. Note they are made of one piece of material.
8. Measure and mark for the sides, and heat for bending over a

strip heater. The plastic is heated from both sides. Take care to heat and bend to a right angle, using a tri-square.

9. Sand the top of the edges and the ends true, using a disc or belt sander.

10. Hand sand and buff the edges of the sides. The ends of the bottom and sides are not buffed. The plain sanded surface will make a stronger glue joint.

11. Lay out and cut the end of clear and white plastics; laminate the ends in the laminating press.

12. Machine sand the edges of the ends.

13. Hand sand and buff the ends to a high polish.

14. Assemble by gluing the ends to the ends of the bottom and sides.

15. Drill the holes for the hinge pins and assemble the top.

Questions on Laminating Clear Plastic

1. Name three methods of laminating that do not require a laminating machine.
2. What is the correct temperature at which to laminate watch parts or coins in acrylic plastic, using the press?
3. What is the correct procedure in making a sandwich for laminating?
4. What type of plastic is used to laminate cards or photographs?
5. What causes foggy or milky appearances around a paper item laminated? How may this be prevented?
6. What is the normal pressure drop during the period of laminating?
7. What should be done if there is a 100 pound pressure drop?
8. How much pressure is needed to laminate photographs?
9. What are the major elements used to assure good results in laminating?

19 SAMPLE PLASTIC PROJECTS

- *Plastic chimes (pictured on cover).*

Bill of Materials in Inches

1—⅛ x 3 x 6	plastic
25—1/16 x 1¼ x 1¼	plastic
5 feet of fishing line	

Procedure

1. Mark off and saw out a semicircle from the ⅛″ stock.
2. Sand the edges smooth, using the disc sander.
3. Hand sand and buff to a high polish.
4. Divide the straight-edge surface into six equal parts. Mark and drill holes, using a 1/16″ bit.
5. Drill a 1/16″ hole in the top of the semicircle.
6. Set the saw fence 1¼″ from the saw blade. Using 1/16″ stock, saw 1¼″ strips. From these strips saw 1¼″ squares.
7. Set the dividers or compass and mark a 1¼″ circle on each square.
8. Using the disc sander, sand these squares round.
9. Buff the discs to a high polish.
10. Use a 1/16″ drill to drill a hole 1/16″ from the edge of each disc.
11. Run a fishing line through these holes and tie the discs 1½″ apart. Make five separate strands. This will make five discs on each strand. Then tie the five strands to the semicircle.
12. Tie a fine wire in the top of the semicircle. This wire is used to hang the chimes. Patios and other outside areas are good places to hang these chimes.

- *Carved book ends.*

Bill of Materials in Inches

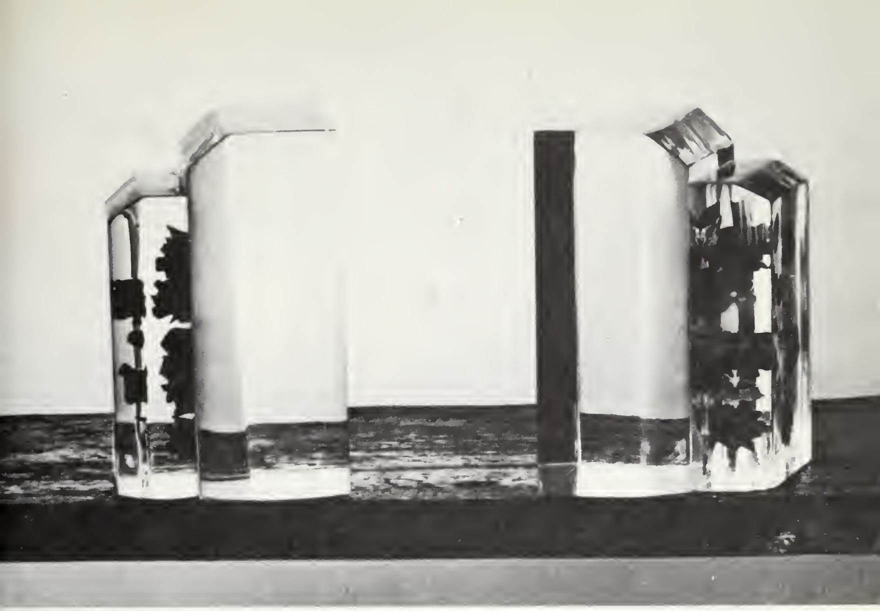
2—1¼ x 4½ x 5	clear for fronts
2—1 x 3 x 4	clear for backs

Tool List

1. Pencil
2. Try square
3. Ruler
4. Bench saw
5. Machine sanders
6. Plane iron
7. Vise
8. Sandpaper.
9. Buffer
10. Carving tool
11. Carving drill
12. Dye equipment
13. Glue pan

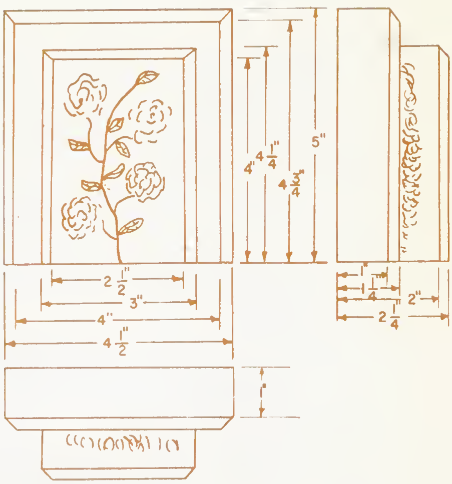
Procedure

1. Lay out.
2. Saw out.
3. Sand out saw marks with machine sander.

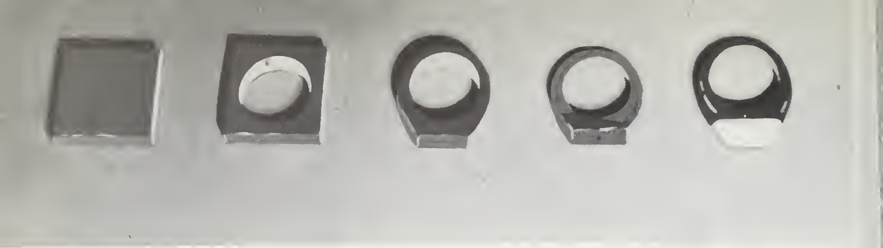


Carved book ends.

4. Lay out chamfers.
5. Sand chamfers by using machine sander with coarse sandpaper.
6. Scrape with plane iron.
7. Sand by hand.
8. Buff.
9. Carve flowers in backs.
10. Apply dye.
11. Apply filler and allow to dry.
12. Carve stems and leaves.
13. Apply dye.
14. Apply filler and allow to dry.
15. Level surface that has been carved on machine sander, using machine with medium sandpaper.
16. Glue backs to fronts.



Carved book ends.



Steps in making a ring.

- *Ring.*

Bill of Material in Inches

1—¼ x 1¼ x 1¼ colored

Tool List

1. Pencil
2. Ruler
3. Try square
4. Circle saw
5. Twist drill (approximately size of finger)
6. Rat-tail file for drill press
7. Drill press
8. Machine sanders
9. Glue pan
10. Buffers

Procedure

1. Lay out.
2. Saw out.
3. Drill hole.
4. File to correct size with rat-tail file in drill press.
5. Shape on machine sander.
6. Glue on set, allow glue to set.
7. Shape on machine sander.
8. Sand by hand.
9. Buff.

- *Chamfered pen stand with emblem.*

Bill of Materials in Inches

1—⅞ x 3 x 5¼	clear blue
2—⅞ x ⅞ x 2¾	black pen holders

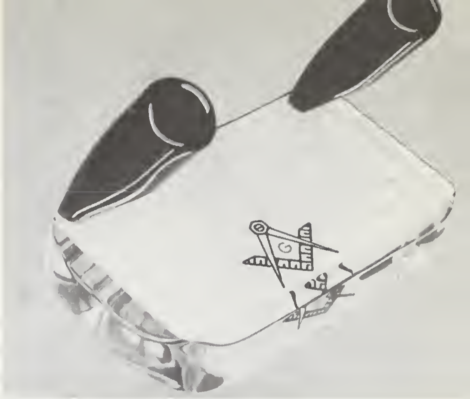
Procedure for Base

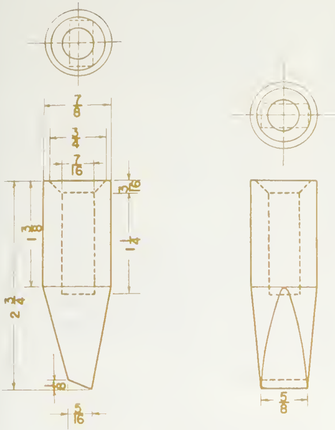
1. Lay out the base 3 x 5¼″, using ⅞″ stock.
2. Saw out the base, using the circle saw.
3. Set the compass at ¾ R (radius) to mark the corners.
4. Using a band saw, cut the round corners.
5. Using a disc sander, sand the edges smooth.
6. Lay out 3⁄16″ chamfers.
7. Sand the chamfers with a disc sander.
8. Hand sand the edges and buff.
9. Engrave the design by using the pantograph machine.
10. Apply color lacquer in the engraved design.

Procedure for Penholders

1. Lay out two pieces of black plastic, ⅞ x ⅞ x 2¾″.
2. Saw out the material, using the circle saw.
3. Drill a hole in each piece 1¼″ deep with a 7⁄16″ drill.
4. Shape by sanding on the disc sander.
5. Hand sand and buff.
6. Cement the penholders to the base.

Chamfered pen stand with emblem.

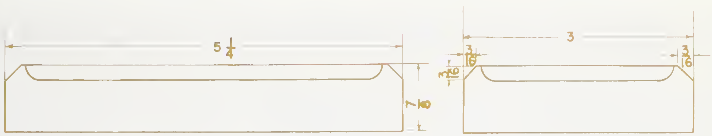


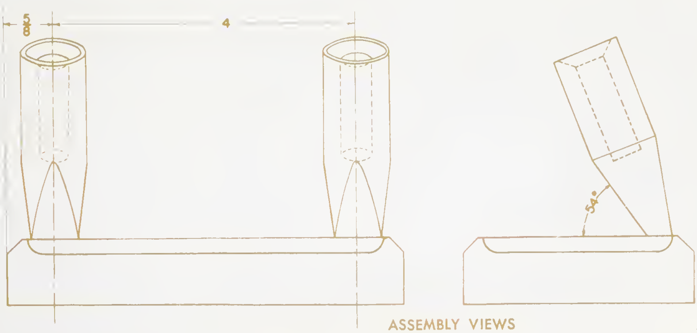


FRONT AND SIDE VIEWS OF PENHOLDER

DESIGN ENGRAVED IN UNDERSIDE OF BASE

How to make chamfered stand.





ASSEMBLY VIEWS

• ***Paperweight.***

Bill of Materials in Inches

1—1½ x 3 x 3	clear
1—1⁄16 x 3 x 3	colored

Tool List

1. Pencil
2. Ruler
3. Try square
4. Circle saw
5. Machine sanders
6. Plane iron
7. Buffer
8. Carving tools
9. Glue pan
10. Dyeing tools
11. Vise

Procedure

1. Lay out.
2. Saw out.
3. Shape on machine sander.
4. Scrape with plane iron.
5. Hand sand with fine sandpaper.
6. Buff.
7. Carve flower.
8. Apply dye.
9. Apply powder and mix.
10. Allow to dry.
11. Carve leaves.
12. Apply dye.
13. Apply powder and mix.
14. Allow to dry.
15. Sand bottom level on machine sander.
16. Glue on bottom.
17. Allow glue to set.
18. Shape bottom on sander.
19. Scrape edge of bottom.
20. Hand sand.
21. Buff.

• ***Ear screws.***

Bill of Materials

2—¼ x 1 x 1	clear
2—1⁄16 x ¾ x ¾	colored

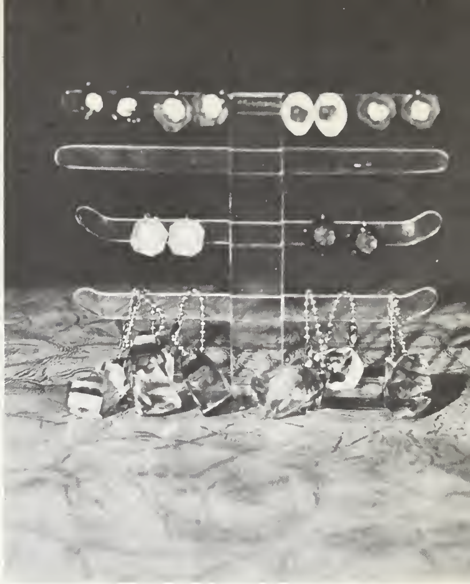
1. Pencil
2. Circle saw

Different designs of carved paperweights.

3. Carving drill
4. Carving tool
5. Dyeing equipment
6. Machine sanders
7. Gluing equipment
8. Buffer

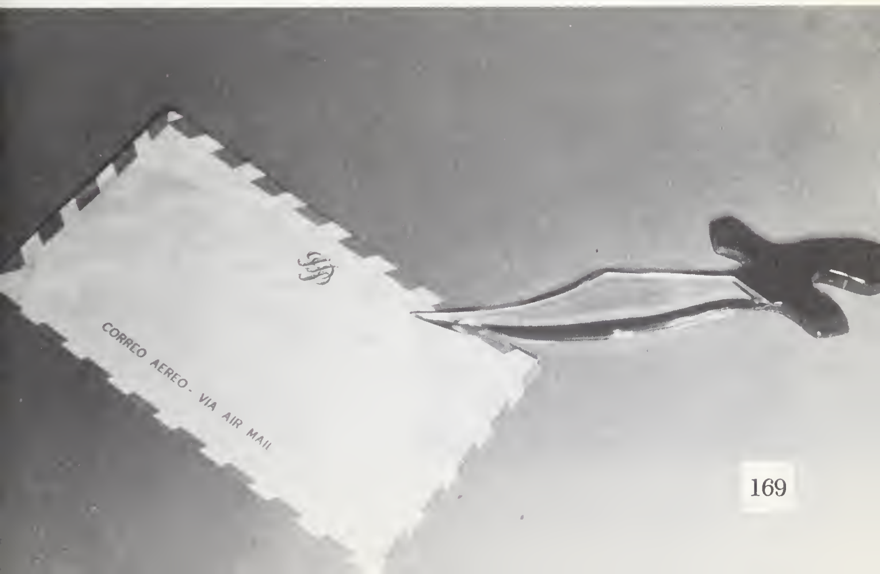
Procedure

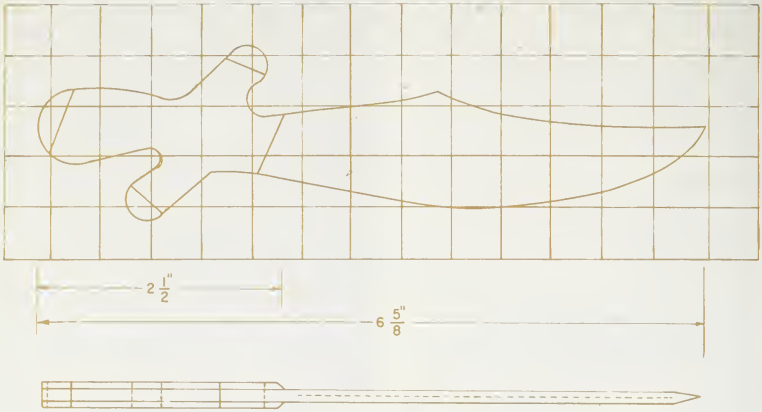
1. Lay out.
2. Saw out.
3. Carve.
4. Apply dye.
5. Apply powder and mix.
6. Allow to dry.
7. Smooth bottom on machine sander.
8. Glue on colored backs, allow to dry 30 minutes.
9. Shape on machine sander.
10. Smooth on fine sander.
11. Buff.
12. Glue on metal screws.
13. Allow to dry 24 hours.



Rack displaying carved ear screws and key chains.

Letter opener.





Letter opener.

• ***Letter opener.***

Bill of Materials in Inches

1–1/8 x 2 x 6	clear–blade
2–1/8 x 2 x 2½	colored–handles
3–¼ x ½ x ½	colored–tips

Tool List

1. Pencil
2. Ruler
3. Pattern
4. Scissors
5. Jig saw
6. Glue pan
7. Machine sander
8. Rat-tail file for drill press
9. Drill press
10. Buffer

Procedure

1. Make pattern.
2. Trace pattern on plastic.
3. Saw out with jig saw.
4. Glue on one handle.
5. Saw out handle with jig saw.
6. Glue on other handle.
7. Saw out handle with jig saw.
8. Shape on machine sander.
9. Level parts for tips.
10. Saw out tips.
11. Glue on tips. Allow glue joint to set.

Steps in making twisted handle letter opener.

12. Shape on sander.
13. Smooth inside curves, using rat-tail file in drill press.
14. Sand by hand.
15. Buff.

• ***Bracelet.***

Bill of Material in Inches

1—⅛ x 1¼ x 5½ colored

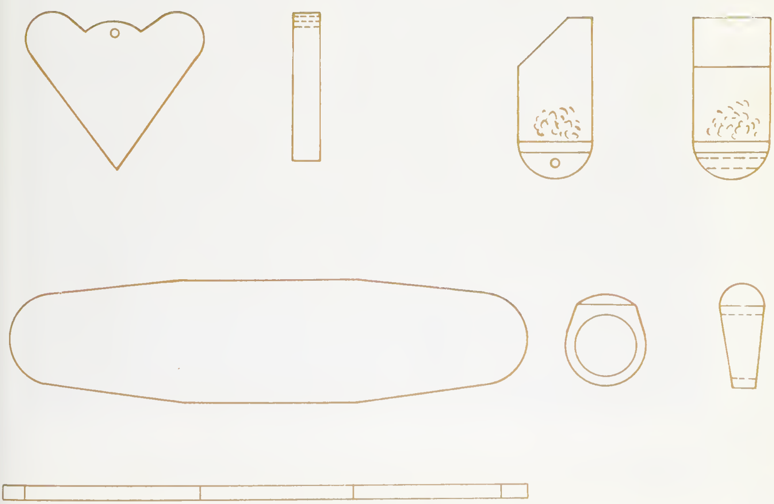
Tool List

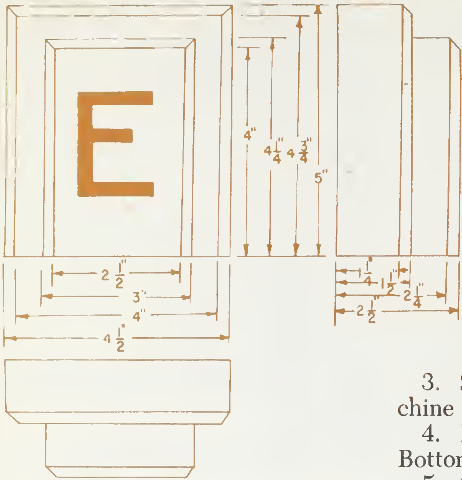
1. Pencil
2. Ruler
3. Try square
4. Circle saw
5. Machine sanders
6. Engraving machine
7. Plane iron
8. Buffer
9. Paintbrush
10. Bracelet mold
11. Electric oven
12. Vise

Procedure

1. Lay out.
2. Saw out.
3. Shape on machine sander.
4. Scrape.
5. Sand by hand.
6. Buff.
7. Write name on.
8. Apply paint, allow to dry 24 hours.
9. Buff.
10. Heat in oven and mold.

Simple projects. *Left to right top*—front view and side view of necklace, front view and side view of carved key chain. *Left to right bottom*—side view and top view of name bracelet, front view and side view of ring.





Initial book ends.

• ***Initial book ends.***

Bill of Materials in Inches

2–1½ x 4½ x 5	clear
2–1 x 3 x 4½	clear

Tool List

1. Pencil
2. Try square
3. Circle saw
4. Machine sander
5. T bevel
6. Marking gauge
7. Plane iron
8. Vise
9. Engraving machine
10. Gluing equipment
11. Paint
12. Paintbrush

Procedure

1. Lay out.
2. Saw out.
3. Sand saw marks out on machine sander.
4. Mark off chamfers. NOTE: Bottom has no chamfer.
5. Sand off chamfers. (Check often with T bevel.)
6. Scrape with plane iron.
7. Hand sand, using fine sandpaper.
8. Buff.
9. Engrave initial.
10. Apply paint.
11. Allow to dry and buff off excess paint.
12. Glue up.

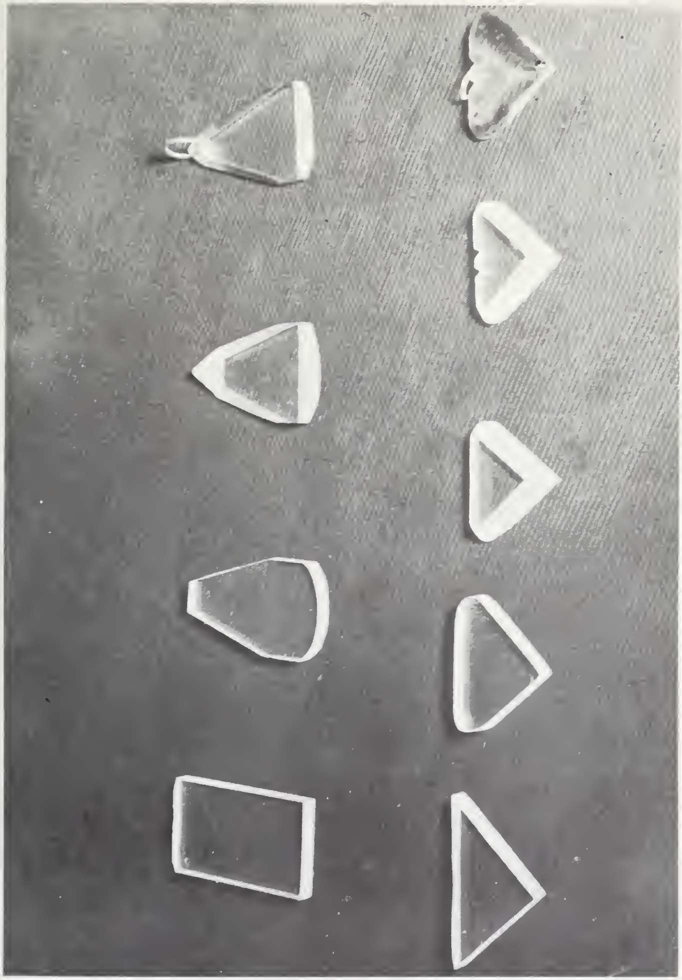
• ***Necklace.***

Bill of Materials in Inches

1–¼ x triangle 1¼ sides	colored
1–1¼ of paper clip	

Tool List

1. Pencil
2. 45° triangle
3. Ruler
4. Bench saw
5. Machine sanders
6. Handsaw file



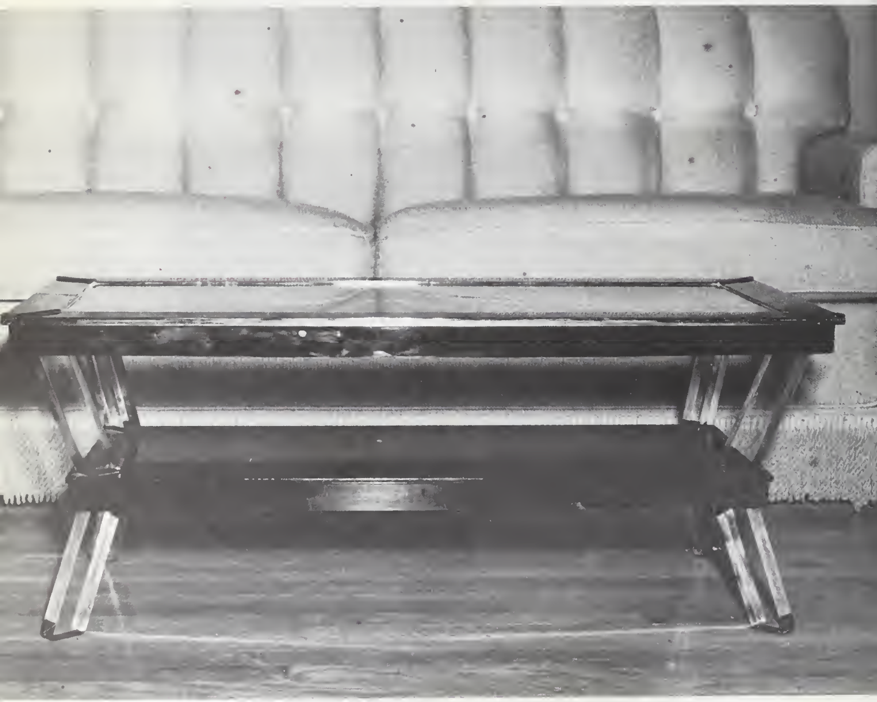
Steps in making a zipper pull and necklace.

7. Buffer
8. 1/16″ twist drill
9. Drill press
10. Paper clip
11. Pliers
12. Vise

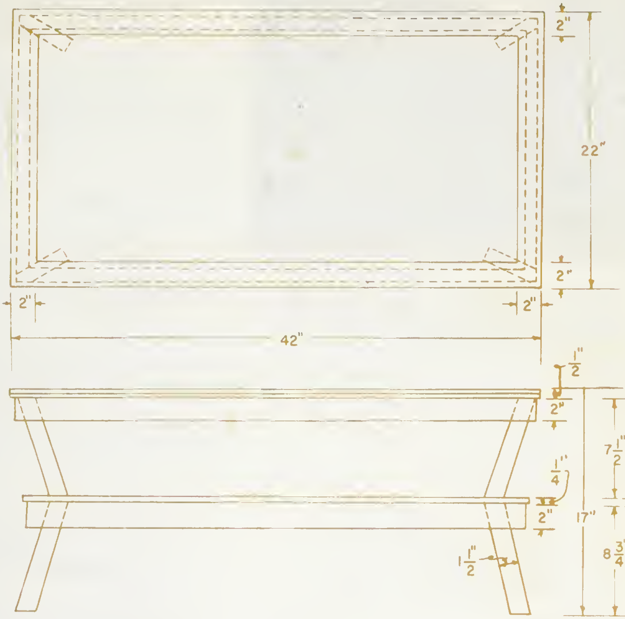
Procedure

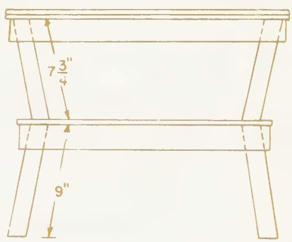
1. Lay out triangle with all sides 1¼″.
2. Cut out.
3. Shape on machine sander.
4. File groove in top, with handsaw file.
5. Smooth on fine machine sander.
6. Sand all white streaks out by hand.
7. Buff. Use cutting wheel first.
8. Mark off for hole.
9. Drill hole with 1/16″ drill, using drill press.
10. Make link with paper clip.

Coffee table, made of black and clear plastic.



Coffee table, made of black and clear plastic.





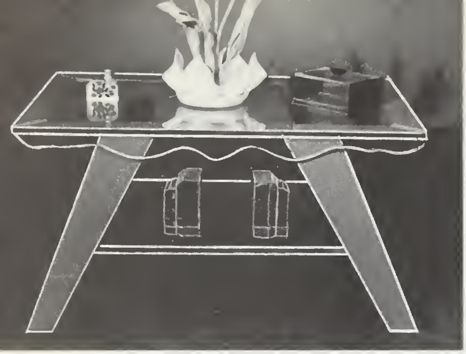
• *Coffee table.*

Bill of Materials in Inches

4—1½ x 1½ x 9	clear—legs for bottom section
4—1½ x 1½ x 7¾	clear—legs for top section
2—¼ x 2 x 22	black—sides for top border
2—¼ x 2 x 22	black—ends for top border
1—¼ x 22 x 42	clear—top
2—¼ x 2 x 41½	black—sides for top rails
2—¼ x 2 x 21	black—ends for top rails
2—¼ x 2 x 41	black—sides for bottom rails
2—¼ x 2 x 18	black—ends for bottom rails
1—¼ x 18 x 41	black—bottom shelf

Tool List

1. Pencil
2. Ruler
3. Framing square
4. Try square
5. T bevel
6. Bench saw



Plastic coffee table. Also book ends, cigarette lighter, cigarette box, and cattail centerpiece in bowl.

7. Machine sanders
8. Plane iron
9. Vise
10. Sandpaper
11. Buffer
12. Glue pan (large)
13. 45° triangle
14. Miter saw

Procedure

A. Legs.

1. Lay out.
2. Saw out.
3. Sand saw marks out on machine sander.
4. Scrape with plane iron.
5. Sand by hand.
6. Buff.
7. Sand end at proper angle on machine sander using machine with medium sandpaper.

B. Top.

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape with plane iron.
5. Hand sand.
6. Buff.
7. Check border joints.
8. Glue border to top.
9. Glue rails to top.

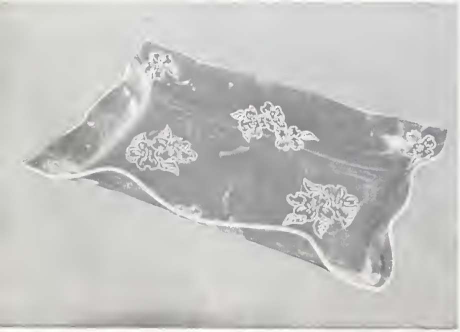
C. Bottom Shelf.

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape with plane iron.
5. Buff.
6. Glue rails to shelf.

D. Assemble.

1. Glue legs to top.
2. Glue bottom legs to shelf.
3. Glue top section to bottom section.

Tray with engraved design.



• ***Engraved tray.***

Bill of Material in Inches

1—⅛ x 14 x 17 clear plastic

Tool List

1. Pencil
2. Framing square
3. Circle saw
4. Machine sander
5. Vise
6. Plane iron

7. Buffer
8. Vibro tool
9. Pattern
10. Carbon paper
11. "Scotch" tape
12. Electric oven
13. Mold.
14. Hot pads and gloves

Procedure for Engraved Tray

(See Chapter on "Engraving.")

1. Lay out.
2. Saw out.
3. Sand out saw marks with machine sander.
4. Scrape with plane iron.
5. Hand sand, using fine sandpaper.
6. Buff.
7. Fasten design on under side of plastic.
8. Engrave design using "Vibro" tool.
9. Heat in oven until plastic is flexible.
10. Place in mold and allow to cool.

• ***Lazy Susan.***

Tool List

1. Compass
2. Ruler
3. Pencil
4. Band saw
5. Machine sander
6. Vise
7. Buffer
8. Circle saw
9. Plane iron
10. Drill press
11. ⅛″ drill
12. Glue pan

Bill of Materials in Inches

1—¼ x 16	disc, for tray
6—1 x 2½	rods, clear, for post
1—½ x 44	rod, for fence
4—1½ x 2	rods, for upright
1—¼ x 7	disc, for base
4—1 x 1 x 1	black, for feet

Procedure

A. Disk

1. Lay out.
2. Saw out.
3. Sand saw marks out with machine sander.
4. Hand sand with fine sandpaper.
5. Buff.

B. Post

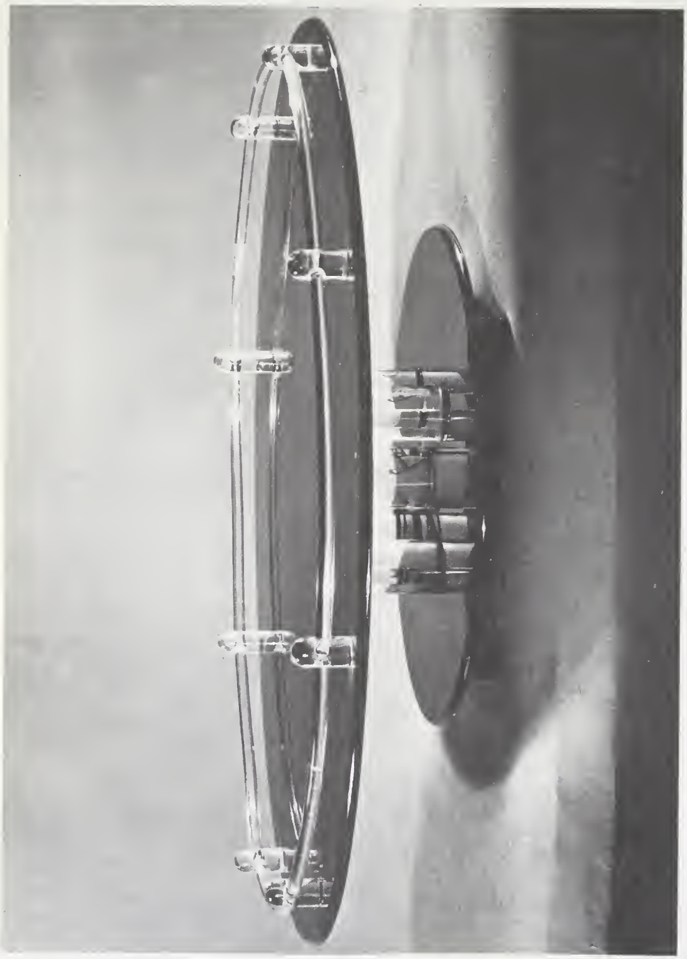
1. Lay out.
2. Saw out.
3. Shape on machine sander.
4. Hand sand with fine sandpaper.
5. Buff all except bottom of post.
6. Sand bottoms level on machine sander.
7. Mark off for ⅛″ holes.
8. Drill holes.
9. Glue on 16″ disk ¾″ from edge, spaced equally.

C. Uprights

1. Lay out.
2. Saw out.
3. Sand ends level on machine sander.
4. Buff all except ends.

D. Feet

1. Lay out.
2. Saw out.



Lazy Susan.

3. Sand saw marks out on machine sander.
4. Scrape with plane iron.
5. Hand sand with fine sandpaper.
6. Buff.

E. Assemble

1. Glue feet to base.
2. Glue uprights to top part of tray.
3. Glue uprights to base of tray.
4. Weave ⅛″ rod through holes in posts to make fence.

Tray of clear and rose plastic.

• *Tray.*

Bill of Materials in Inches

1—¼ x 14 x 16	rose—bottom
2—¼ x 2½ x 36	clear—sides
2—¼ x ¼ x 10	rose—for handle

Tool List

1. Pencil
2. Framing square
3. Circle saw
4. Machine sander
5. Vise
6. Plane iron
7. Buffer
8. Hot pads and gloves
9. Electric oven
10. Glue pan
11. Medicine dropper

Procedure

A. Bottom

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape.
5. Hand sand, using fine sandpaper.
6. Buff.

B. Sides

1. Lay out.
2. Saw out.
3. Saw grooves ¼″ wide ⅛″ deep in center of sides by setting saw fence in proper position and the saw blade ⅛″ above the saw table top. The saw kerf is only about ⅛″. Therefore it will be necessary to adjust the fence and saw through two or three times.
4. Sand edges on machine sander to remove saw marks.
5. Scrape with plane iron.
6. Hand sand, using fine sandpaper.
7. Buff.

C. Handles

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape with plane iron.
5. Hand sand, using fine sandpaper.
6. Buff.

Carved salt-pepper shaker and glued-up salt-pepper shaker.

D. ASSEMBLE

1. Heat sides in oven.
2. Place around bottom with edges of bottom going in grooves.
3. Apply glue with medicine dropper, and hold until the plastic cools.
4. Heat handles.
5. Shape handles and glue on ends.

• ***Carved salt-pepper shaker.***

Bill of Materials in Inches

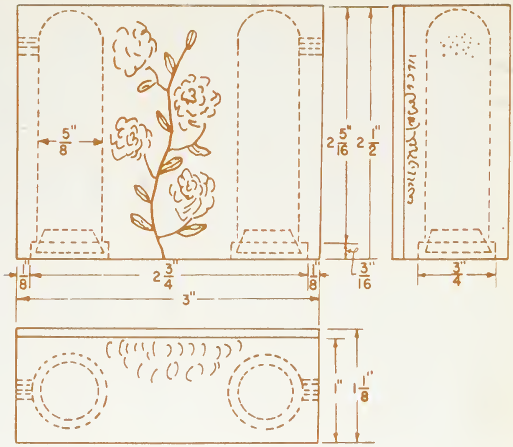
1—1 x 2½ x 3	clear
1—⅛ x 2½ x 3	colored
2—soft wood stoppers	

Tool List

1. Circle saw
2. Ruler
3. ¾″ twist drill
4. Machine sander
5. Plane iron
6. Vise
7. Buffer
8. Electric oven
9. ⅝″ twist drill
10. ⅟₁₆″ twist drill
11. Drill press
12. Carving tool
13. Carving drill
14. Dyeing equipment

Procedure

1. Lay out.
2. Saw out.
3. Sand saw marks out on machine sander.
4. Scrape with plane iron.
5. Hand sand.
6. Buff.
7. Mark off for holes.
8. Drill holes in bottom ¾″ in diameter ³⁄₁₆″ deep.
9. Drill the rest of the hole with ⅝″ drill.
10. Make stopper.
11. Carve flowers from back between the holes.
12. Apply color.
13. Apply molding powder and mix.



Carved salt-pepper shaker.

14. Allow to dry.
15. Carve leaves.
16. Apply color.
17. Apply molding powder and mix.
18. Allow to dry.
19. Smooth on machine sander.
20. Glue on back.
21. Shape edge of back.
22. Scrape, sand and buff.
23. Drill small holes in side.

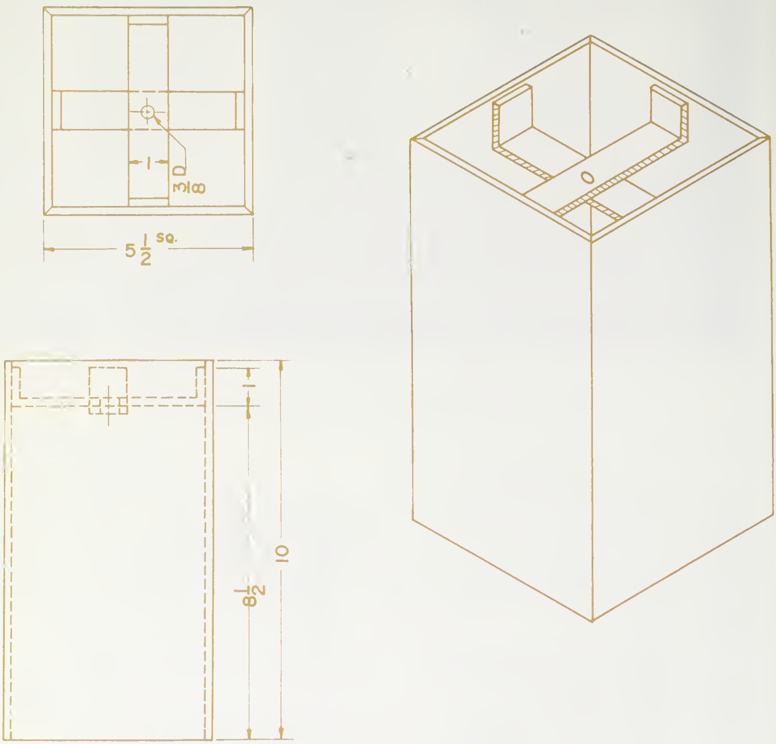
- ***Swag chain lamp (pictured on cover).***

Bill of Materials in Inches

1—10 x 22 (1/16 to 1/8 thick)	plastic—opaque, white or clear, Acrylite or Plexiglas
2—3/16 x 1 x 7½	clear plastic
8 to 10 ounces of plastic pellets	
Epoxy resin and epoxy hardener	
Ethylene dichloride	
Light fixtures, chain, and ceiling or wall hooks	

Procedure

1. Saw out one piece of 10 x 22″ plastic, which is 1/16″ to 1/8″ thick.
2. Set the saw fence 5½″ from the center of the blade.
3. Turn the saw blade up in order to saw no more than halfway through the thickness of the plastic.
4. Run the strip of plastic over the saw, making a slight groove 5½″ from the end. Turn the plastic around and make another groove on the other end.
5. Set the saw fence 11″ from the center of the blade and saw a



Drawings for swag chain lamp.

groove in the center. These grooves serve two purposes: (a) they help in placing the plastic on the strip heater accurately; (b) the grooved section will become flexible before the full thickness of the rest of the strip, therefore giving a more accurate bend.

6. Place the plastic on the strip heater with a groove directly over the heating element. Hold the plastic in place until it is flexible. Bend the plastic, using a try square to make a right angle. Follow the same procedure in forming the other bends.

7. Place the corner, formed by the two ends, in a glue pan. Pour in just enough ethylene dichloride to cover the bottom of the pan. Allow the plastic to soak in the glue for 5 minutes. Set the plastic frame on one end and allow the glue joint to set for 30 minutes.

8. Saw out two pieces of plastic, 3/16 x 1 x 7½″.

9. Set the saw fence 1″ from the blade. Set the saw 1/16″ above the table top. With this setting, saw a groove across each end of the plastic strips. Move the fence the thickness of the blade further away from the saw and repeat the sawing. This will make the grooves twist the width of the saw blade.

10. Sand these strips smooth, using the disc sander with medium sandpaper.

11. Scrape and hand sand the edges.

12. Buff to a high polish.

13. Cement the strips together, making a crossbar.

14. Drill a ⅜″ hole in the center of this bracket for the lamp nipple and light socket. If the hole is not in the center, the light will not hang straight.

15. Heat the ends at the grooves and bend to right angles. This is done by heating over a strip heater. Care must be taken to place the grooves directly over the heating element, using a try square for an accurate bend.

16. Sand the outside of the upright ends to assure a level glue joint.

17. Cement the bracket onto the lamp shade frame ½″ below the top. Soak the upright ends of the bracket in ethylene dichloride and cement to the frame. It is important that this crossbar be in the center and at right angle to the sides. Place a weight directly over the crossbar and allow the glue joint to set.

18. Mix enough epoxy resin and epoxy hardener to cover one of the four outside surfaces of the lamp. A disposable paper cup should be used to mix the epoxy cement. The mixing proportions are 50 percent hardener and 50 percent resin. After the hardener and resin are thoroughly mixed, cover the surface with a thin coat. Use a newspaper between the lamp and the worktable.

19. Cover this wet surface with colored plastic pellets. Care should be taken to get an even layer of pellets on the surface. Some of these pellets will fall off onto the paper, but they can be used later. Allow the cement to set for 45 minutes to an hour, and repeat the same procedure until all four surfaces are covered. The color design of this lamp is determined by the pellets selected. Different colors may be placed on the lamp, or they may be mixed before they are used.

20. Assemble the chain and light fixtures.

21. Mount the wall or ceiling brackets and the light is ready to hang.

To use plastic resin instead of plastic pellets, follow the same procedure through Step 17, after which the following procedure is used:

1. Measure 4 ounces of resin, place in a paper cup, and add white pigment for color. Mix thoroughly.

2. Place newspapers over a level worktable and put the lamp on the papered surface.

3. Place masking tape around the top edge.

4. Pour ¼ of the white resin in a squeeze bottle and add 10 drops of catalyst. Mix the resin and catalyst thoroughly. If the catalyst is added to the resin all at once, it will gel before it can be used. Place the top on the squeeze bottle tightly. All of the resin is colored at the same time to assure the same shade for all sides.

5. Using the squeeze bottle, apply the white resin to the top surface of the lamp. This is done by holding the squeeze bottle about 8 to 10″ above the lamp and moving it around to apply the resin in a spider-web design. Care should be taken to apply an even amount of resin over the surface.

6. Allow the resin to cure for 30 to 40 minutes.

7. Follow the same procedure to mix and apply the white resin on all four sides. Allow the four surfaces to dry for 3 to 4 hours.

8. Measure out 4 ounces of resin and add the desired color.

9. Measure ¼ of this colored resin and add 10 drops of catalyst. Mix the catalyst and resin thoroughly.

10. Follow the same procedure to mix and apply this colored resin as was followed to apply the white resin.

The swag chain lamp is a good project for using up scrap materials. For example, frames can be made of scratched, streaked, or disfigured plastic. Smaller pieces of scrap may be used to create designs.

Example I:

1. Select a number of small plastic pieces of different colors and saw them into 1″ or 1½″ squares.

2. Make a frame of damaged plastic, following the procedure already given.

3. Place pieces of masking tape around the edges of the ends.

4. Mix plastic dust from the saw in ethylene dichloride, making a thin paste.

5. Place the squares of different colors on this paste. Arrange the design as desired. The paste will cement the squares to the plastic frame in 45 minutes to an hour. Repeat the same process to inlay the design on all four surfaces.

Example II:

The same procedure is followed as in Example I except strips of scrap plastic are used. These strips

should be from ⅛″ to ¼″ wide and from 1″ to 5″ long. Another may use triangles, while still another might use odd shapes and designs.

Example III:

1. Make a frame as in Example I.
2. Place the masking tape on the end edges.
3. Select the color or colors wanted. (Three different colors are used on each surface in this example.)
4. Select three paper cups and pour one ounce of ethylene dichloride in each cup. Mix the desired color pigment in each cup.
5. Add plastic dust to one cup to make a thin paste. Then spread this on about ⅓ of an inside surface. Add the plastic dust to the second cup and spread on the surface. Finally, make the third cup of paste and spread on the rest of the surface.
6. Allow the paste to set for 1 hour and repeat the same process to cover the remaining surfaces.

Saturating glass fiber with plastic resin to make the beach ball lamp.

- ***Beach ball lamp (pictured on cover).***

Bill of Materials

Beach ball with smooth surface
Fiber glass mat
Plastic resin
Plastic dyes
Catalyst
Plastic thinner (Plasta-Solve is a good thinner.)
Masking tape
Old newspaper
Mold release

Tool List

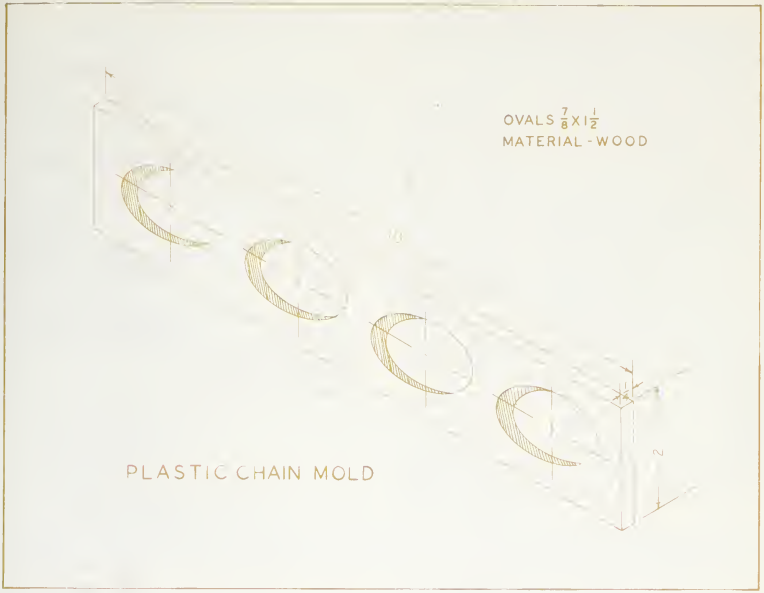
Air pump for bicycle or car
Small paint brush
Measuring cup
Rubber gloves
Aluminum foil pans
Mixing cups
Stirring sticks
Glass jar
Tin snips

Procedure

1. Pump up the beach ball to the size wanted.
2. Cut pieces of fiber glass mat to cover all the ball except for a 4″ circle around the valve. This provides an opening in the lamp for assembling light bulbs and removing the ball when the resin is cured.
3. Use masking tape to tape the fiber glass to the ball at the 4″ circle.
4. Place the ball on top of the glass jar with the valve in the center of the top of this container. Then spray mold release on the ball.
5. Mix enough plastic resin to saturate the fiber glass. For a 10″ lamp, use 4 to 5 ounces. To prepare this resin, add the desired color dye and mix thoroughly. Then add 10 drops of catalyst for each ounce of resin.
6. Using the paint brush, brush the resin into the fiber glass. Take care to brush the resin evenly. Place old newspapers under the container and ball to catch the dripping resin. The beginner may want to saturate one section at a time and permit it to cure. If this is done, mix only enough resin to saturate the one section.
7. Allow the resin to cure. Curing will take from 12 to 24 hours.
8. Deflate the ball and pull it out of the 4″ opening. If the edge of this opening is uneven, it can be smoothed on the disc sander or with a metal cutting file.
9. Determine the colors wanted. Mix 2 to 3 ounces of resin dye and catalyst and then pour in thin layers into the aluminum foil pans. When this resin gels, place gelled resin slabs of different sizes and shapes on the fiber glass frame. The slabs will have to be placed on the upper portion or the gelled plastic will fall off.
10. Mix another 2 to 3 ounces of resin, dye, and catalyst, following the same procedure in mixing and applying. Continue this procedure until the frame is covered with the desired colors of gelled resin.
11. Allow the resin to cure for 24 hours.
12. Drill a 7/16″ hole in the top to assemble the lamp fixtures.

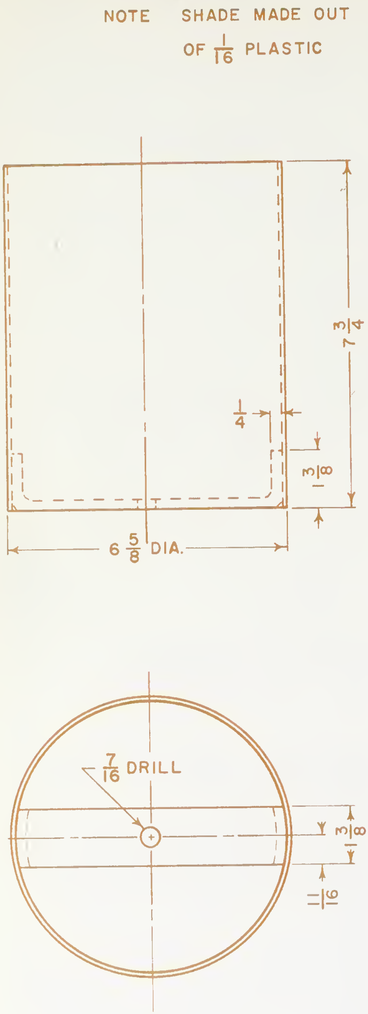
Procedure for Making a Plastic Lamp Chain

1. Determine the link size. An oval, 7/8 x 1½″, made of 3/16″ material is a good size.
2. Make a mold to form the links. To do this, saw out a piece of wood, ¼ x 2 x 10″. Mark four 7/8 x 1½″ ovals, equally spaced on the wood. Drill a ¼″ hole on the inside of these ovals. Use a jig saw or coping saw to saw out the inner portion of the ovals. Smooth the surface by filing and sanding.
3. Using 3/16″ stock, saw out 3/16″ square strips. Amber colored plastic is a good color to use.
4. Saw one strip 3¾″ long. Using the disc sander, sand the ends to a slight bevel.
5. Hand sand and buff the strip.

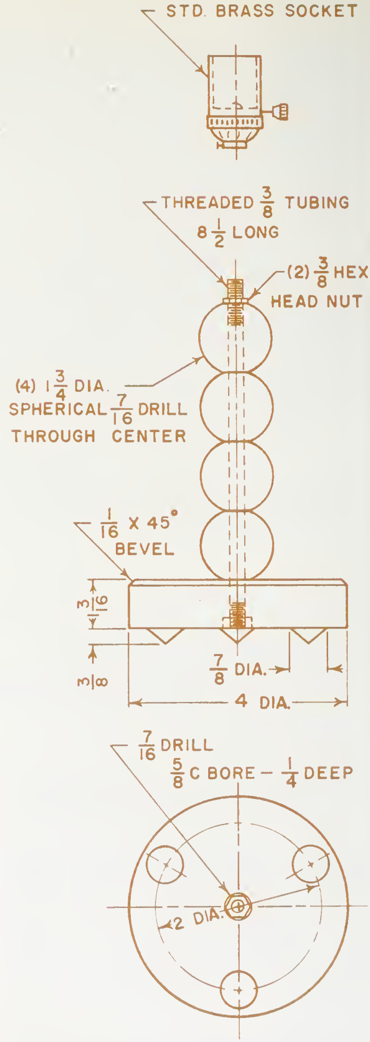


Plastic chain mold to use in making chain for beach ball lamp.

6. Heat in the oven until flexible.
7. Using gloves, place this hot strip of plastic in one of the molds. Check to see if the plastic is the right length. It may be the correct length or it may be a little long or short, depending on how much filing and sanding was needed.
8. Make the second link, correcting the length if needed.
9. Saw all of the strips wanted.
10. Sand and buff the strips, first with the disc sander and then by hand.
11. Heat in the oven and place in the molds. Remove them from the molds before they are completely cool and link them together.
12. Place one or two drops of thick plastic cement on the joint of each link. Allow the cement joint to set for 30 to 40 minutes.
13. Weave the lamp cord wire through the plastic links and assemble the light fixtures.



LAMP SHADE



LAMP STAND

Drawings for table lamp.

- ***Table lamp (pictured on cover).***

Bill of Materials

Sheet plastic in thicknesses of 1/16″, 1/4″, and 1 3/16″ (Acrylite and Plexiglas are good.)
Plastic resin (Polyester casting resin can be used.)
Resin dye
Catalyst
Four glass grape molds
Mold for lamp feet
Lamp fixtures
Threaded tubing
Ethylene dichloride

Tool List

Measuring cup
Paper cups
Stirring sticks
Squeeze bottles
Medicine dropper
Egg crate
Glue pan
Gallon glass jug

Procedure

A. Base

1. Mark off and saw out a 4″ disc, using the 1 3/16″ sheet plastic. Dividers are used to mark the circle, and the band saw is used to saw the plastic.

2. Using the disc sander, sand the edge smooth. Then sand a 1/16″ chamfer on the top of this disc.

3. Hand sand and buff to a high polish.

B. Upright and Feet

1. Measure out the required resin to fill the four grape molds and to make the feet. Place the resin in one of the paper cups and add the desired amount of dye. Stir the dye and resin thoroughly.

2. Add the catalyst to the colored resin. Use 8 to 10 drops of catalyst for each ounce of resin. Stir the catalyst into the resin thoroughly.

3. Pour the colored, catalyzed resin into a squeeze bottle. Place the glass molds in an egg crate and fill the glass molds and the feet mold. Allow this plastic to cure for 24 hours. (To make a mold for the lamp feet, first drill cone-shaped holes in a piece of hardwood. Then build a frame around this wood. Heat a piece of rigid, flexible plastic and, with the use of this wood form and the forming press, form a plastic casting mold.)

4. To remove the plastic from the glass molds, gently break the glass. Using the hands, press the under surface of the feet mold to remove.

5. Using a 7/16″ drill in the drill press, drill a hole in the spheres and base. Care should be taken to drill the holes through the center of the spheres and the base.

C. Lamp Stand

1. Measure and mark for the correct placing of feet as shown in the lower lamp stand drawing. Use a medicine dropper to place 6 to 8 drops of ethylene dichloride in the glue pan. Soak the flat surface of the feet in the ethylene dichloride for 3 or 4 minutes. Place these feet on the base and allow to set for 30 minutes.

2. Place the threaded tubing through the base and spheres. Fasten by tightening the hex nut at the top and bottom of the threaded tubing.

D. Lamp Shade

1. Mark off and saw out a 7¾ x 22″ piece of plastic, using the 1⁄16″ sheet plastic.

2. Heat the plastic in the oven and use the glass gallon jug as a mold to form the plastic.

3. Cover the bottom of the glue pan with ethylene dichloride. Place the plastic in the glue pan so as to have the seam in the glue. Allow the plastic to soak for 3 or 4 minutes. Take the plastic out of the glue and allow to set for 30 minutes.

4. For the bracket, mark off and saw out a 1⅜ x 9⅜″ piece of plastic, using the ¼″ stock. Place this strip of plastic across the end and through the diameter of the shade. Mark a groove on each end of the strip where it meets the shade. These grooves are to aid in heating and bending the plastic. Set the saw and cut the grooves ⅛″ deep.

5. Using the disc sander, sand the ends round and smooth. Sand the sides smooth, using the belt sander.

6. Hand sand and buff to a high polish.

7. Heat the ends on the strip heater, placing the groove directly over the heating unit. When the plastic is flexible, bend it to a right angle.

8. Using the disc sander, sand the uprights of this bracket in an oval shape to fit flush to the inside of the shade.

9. Using a 7⁄16″ drill, drill a hole in the center of the bracket.

10. Soak the ends in glue and cement to the bottom of the shade directly across the center. Allow the glue to set for 30 minutes.

11. Measure out 2 ounces of plastic resin and mix thoroughly with white pigment. Add 20 drops of catalyst and mix.

12. Place the mixed resin in a squeeze bottle and apply it to the inside of the shade in a spider-web design. Hold the squeeze bottle in one hand and the lamp shade in the other. Hold the lamp shade by the bracket, moving both the shade and the squeeze bottle around while applying the resin. Keep turning the shade to keep the resin from dripping. This movement must be continued for about 15 minutes until the plastic gels. Then mix and apply the resin on the outside in the same manner. Allow the resin to cure for 24 hours.

13. Measure 4 ounces of resin and mix with the desired color of dye. Pour 2 ounces of colored resin in a container and add 20 drops of catalyst. Mix thoroughly.

14. Place the mixed resin in a squeeze bottle and apply to the inside of the shade, following the same procedure as before. Be sure to cover all areas that were not covered with the white resin.

15. Add catalyst to the other 2 ounces of colored resin and apply on the outside. Allow the resin to

cure for 24 hours. Assemble the lamp shade and light fixture in the lamp stand.

- ***Lamp, clock stand, and box.***

Lamp Tool List

1. Pencil
2. Try square
3. Straightedge
4. Circle saw
5. Carving tools
6. Machine sander
7. Dyeing equipment
8. Vise
9. Plane iron
10. Buffer
11. Electric oven
12. Jig to form base
13. Hot pads and gloves
14. Drill press
15. ⅜″ twist drill
16. Gluing equipment

Bill of Materials in Inches

Lamp	
2—⅜ x 2¼ x 10	clear, for upright
2—⅛ x 2¼ x 10	black, back for upright
1—¼ x 3 x 7	black, for base
1—¼ x 1½ x 1¾	clear, for bottom of upright
1—¼ x 1½ x 2¼	clear, for top of upright

Lamp, clock, and box.

Clock	
1—1¼ x 4 x 6	clear, for clock
1—¼ x 2½ x 12	black, for base
4—¼ x 1 x 1	black, for feet
2—2½ x 2½ x 2½	clear, for carved parts on base
Box	
2—1 x 2¾ x 5	clear, for ends
2—¼ x 2¼ x 5	black, for sides
1—⅛ x 4 x 5	black, for bottom
1—¼ x 4 x 5	clear, for top

Procedure

A. Uprights

1. Lay out.
2. Saw out.
3. Carve designs in clear parts.
4. Apply dye.
5. Apply plaster of paris.
6. Sand back surface smooth on machine sander.
7. Glue on black parts to clear.
8. Sand edges on machine sander.
9. Scrape all edges except bottoms.
10. Buff all edges except bottoms.

B. Base

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape with plane iron.
5. Hand sand, using fine sandpaper.
6. Buff.
7. Place in electric oven.
8. When plastic is flexible, take out of oven, using hot pads or gloves.
9. Form in jig and allow to cool.
10. Drill hole in base.

C. Top and Braces

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Hand sand, using fine sandpaper.
5. Buff.
6. Drill ⅜″ hole in top.

D. Assemble

1. Fasten nipple in top part.
2. Glue uprights to base.
3. Glue top to uprights.
4. Glue braces to base and uprights.

Clock Stand Tool List

1. Try square
2. Ruler
3. Pencil
4. Circle saw
5. Machine sander
6. Drill press
7. 1″ twist drill
8. Cutter used on drill press
9. Carving tools
10. Vise
11. Plane iron
12. Buffer
13. Dyeing equipment
14. Gluing equipment

Procedure

A. Clear Block for Clock Holder

1. Lay out.
2. Saw out.
3. Sand saw marks out with machine sander.
4. Scrape with plane iron.
5. Hand sand, using fine sandpaper.

6. Buff.
7. Drill 1″ hole.
8. Cut out with cutter on drill press to desired size.
9. Carve designs.
10. Apply dye.
11. Apply plaster of paris; allow to dry.
12. Buff again.

B. Carved Cubes

1. Lay out
2. Saw out.
3. Shape to desired design on machine sander.
4. Hand sand, using fine sandpaper.
5. Buff.
6. Carve design.
7. Apply dye.
8. Apply plaster of paris; allow to dry.

C. Base and Feet

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape with plane iron.
5. Hand sand, using fine sandpaper.
6. Buff.

D. Assemble

1. Glue feet to base.
2. Glue clock holder in center of base.
3. Glue carved blocks on ends of base.

Box Tool List

1. Try square
2. Pencil
3. Circle saw
4. Machine sander
5. Vise
6. Plane iron
7. Drill press and cutter for ends
8. Carving tools
9. Dyeing equipment
10. Buffer
11. Gluing equipment

Procedure

A. Ends

1. Lay out.
2. Saw out.
3. Sand out saw chips on machine sander.
4. Shape on drill press with cutter.
5. Hand sand.
6. Buff.

B. Bottom and Sides

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape top edges of sides and edges of bottom with plane iron.
5. Hand sand and buff parts that were scraped.
6. Glue unpolished edges of sides to bottom part of box, allow glue to set.
7. Sand ends of bottom and sides, smooth and true on machine sander.
8. Glue on ends of both.

C. Top

1. Lay out.
2. Saw out.
3. Carve design.
4. Apply dye.
5. Apply plaster of paris and allow to dry.

6. Saw grooves for sides.
7. Sand on machine sander.
8. Gauge with plane iron.
9. Hand sand with fine sandpaper.
10. Buff.

- ***Trinket box.***

Bill of Materials (see drawing, page 195)

Tool List

1. Try square
2. Pencil
3. Circle saw
4. Band saw
5. Machine sander
6. Plane iron
7. Vise
8. Buffer
9. Mold
10. Electric oven
11. Hot pads and gloves
12. Gluing equipment

Procedure

A. Ends

1. Lay out.
2. Saw out.
3. Shape on machine sander.
4. Scrape with plane iron.
5. Hand sand, using fine sandpaper.
6. Buff.

B. Curved Part

1. Lay out.
2. Saw out.
3. Heat in oven until plastic is flexible.
4. Form by placing in mold.
5. Sand edges and ends level on machine sander.
6. Scrape edges.
7. Hand sand edges.
8. Buff edges.

C. Top

1. Lay out.
2. Saw out.
3. Sand saw marks out on machine sander.
4. Scrape with plane iron.
5. Hand sand, using fine sandpaper.
6. Buff.
7. Saw grooves.

D. Handle

1. Lay out.
2. Saw out.
3. Shape on machine sander.
4. Hand sand.
5. Buff.

E. Assemble

Glue ends to curved part and handle to top.

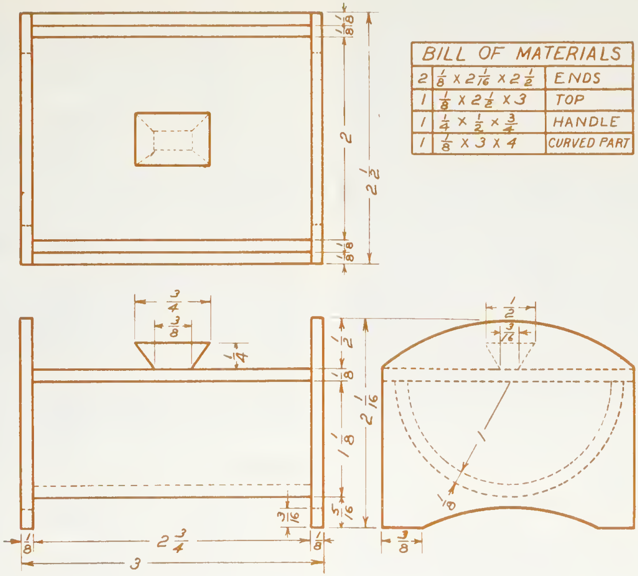
- ***Trinket box with plastic flower design.***

Bill of Materials in Inches

1—1/16 x 6 x 6	white, for flower petals
1—1/16 x 2 x 10	green, for leaves
1—1/4 x 1/4 x 3	green, for stem
1—1/8 x 5 x 9	black, for top
1—1/8 x 4 1/4 x 8 1/4	black, for bottom
2—1/8 x 2 1/2 x 8 3/4	black, for sides
2—1/8 x 2 1/2 x 4 1/2	black, for ends
4—1/4 x 1 x 1 1/2	black, for feet
2—1/8 x 1 x 9	sides of top
2—1/8 x 1 x 4 3/4	ends of top

Tool List

1. Pencil
2. Try square
3. Patterns for petals and leaves
4. Jig saw



Round-bottom box.

5. Circle saw
6. Machine sander
7. Electric stove
8. Vise
9. Plane iron
10. Gloves
11. Pliers
12. Buffer
13. Gluing equipment

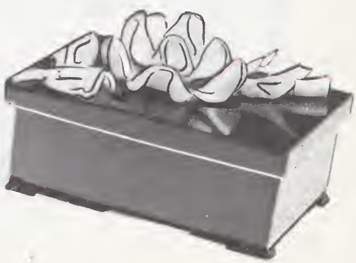
Procedure

A. Bottom

1. Lay out.
2. Saw out.
3. Sand saw marks out on machine sander.

B. Sides and Ends

1. Lay out.
2. Saw out.
3. Sand saw marks out on machine sander.



Trinket box with plastic flower design top.

4. Scrape top edges of ends and sides.
5. Scrape end edges of sides.
6. Hand sand scraped surfaces and buff.
7. Glue ends to bottom.
8. Glue sides to bottom and ends.

C. Top

1. Lay out.
2. Saw out.
3. Sand saw marks out on machine sander.
4. Scrape edge with plane iron.
5. Sand by hand with fine sandpaper.
6. Buff.
7. Saw out rim.
8. Scrape, sand, and buff edges of that one not to be glued.
9. Glue rims to top.

D. Flower

1. Make patterns of petals.
2. Transfer patterns to plastic.
3. Saw out.
4. Sand on machine sander.
5. Hand sand.
6. Buff.
7. Heat until flexible.
8. Form by hand, using gloves.
9. Glue to top.

• ***Planter with candle holders.***

Bill of Materials in Inches

1—⅛ x 5 x 14	green	bottom and ends of planter
2—⅛ x 2½ x 11	green	sides of planter
2—⅛ x 3½ x 3½	green	top for candle holder
2—¼ x 2¼ x 2¼	green	base for candle holder

Tool List

1. Pattern for sides
2. Pencil
3. Jig saw
4. Circle saw
5. Machine sander
6. Jig to form bottom and ends
7. Mold for candle holder
8. Plane iron
9. Vise

Planter with candle holders—made of green plastic.

10. Electric stove
11. Gloves
12. Gluing equipment

Procedure

A. Planter

1. Make pattern for sides.
2. Transfer pattern to plastic.
3. Saw out.
4. Sand on machine sander.
5. With plane iron, scrape edges not to be glued.
6. Hand sand scraped edges and buff.
7. Place part for bottom and ends in oven; allow to heat until flexible.
8. Form in jig and allow to cool.
9. Glue up.

B. Candle holders

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape with plane iron.
5. Hand sand with fine sandpaper.
6. Buff.
7. Place top parts in oven and allow to heat until flexible.
8. Place top parts in mold and allow to cool.
9. Glue up.

- ***Carved penholder.***

Bill of Materials in Inches

1—¾ x 3½ x 3½	clear
1—1/16 x 3½ x 3½	black
Penholder (buy)	

Tool List

1. Pencil
2. Try square

Carved penholder.

3. Circle saw
4. T bevel
5. Carving tools
6. Drill press
7. 3/16″ twist drill
8. Screwdriver
9. Vise
10. Plane iron
11. Machine sander
12. Buffer
13. Gluing equipment

Procedure

1. Lay out.
2. Saw out.
3. Carve design in clear.
4. Fill design with plaster of paris mixed with water. Allow to dry.
5. Sand bottom of clear plastic on machine sander.
6. Glue black plastic to bottom and allow glue to set.
7. Shape on machine sander.
8. Scrape with plane iron.

Double penholder.

9. Hand sand.
10. Buff.
11. Drill hole and assemble penholder.

• ***Double penholder.***

Bill of Materials in Inches

1—½ x 5½ x 5½	black	bottom of base
1—¼ x 4½ x 4½	white	top of base
1—1¾ x 1¾ x 3½	black	glued-up stock for penholder

Tool List

1. Compass
2. Band saw
3. Circle saw
4. Gluing equipment
5. Drill press and twist drill for penholder
6. Machine sander

Procedure

1. Lay out.
2. Saw out.
3. Glue up black for penholder.
4. Shape.
5. Sand on machine sander.
6. Hand sand.
7. Drill holes.
8. Buff.
9. Glue up.

• ***Display rack.***

Bill of Materials in Inches

1—½ x 1¼ x 48 clear

Tool List

1. Pencil
2. Yardstick
3. Try square
4. Circle saw
5. Machine sander
6. Plane iron
7. Vise
8. Buffer
9. Engraving machine
10. Jig for forming
11. Oven, hot pads, and gloves

Procedure

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape with plane iron.
5. Hand sand.
6. Buff.
7. Engrave lettering.
8. Heat in oven, place in jig, allow to cool.

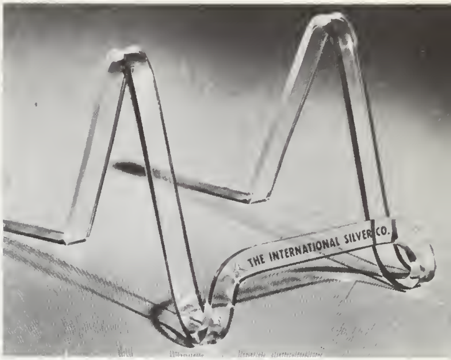
• ***Plastic block with clock built in.***

Bill of Material
(determined by size of clock)

Tool List

1. Try square

Costume items: orchid pin, brooch and ear screws, and buttons.

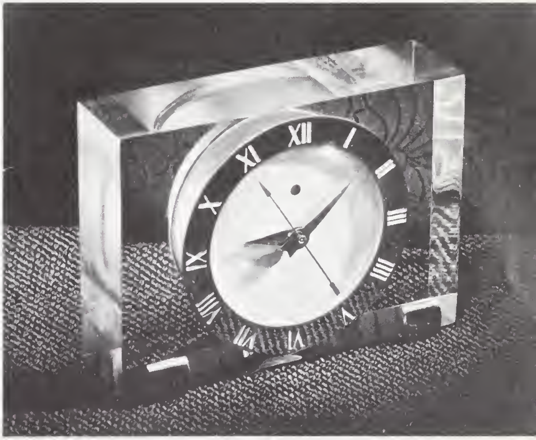


Display rack.

2. Pencil
3. Circle saw
4. Drill press
5. 1″ twist drill
6. Cutter for drill press
7. Vise
8. Machine sander
9. Plane iron
10. Buffer

Procedure

1. Lay out.
2. Saw out.
3. Sand saw marks out on machine sander.
4. Scrape with plane iron.
5. Sand by hand, using fine sandpaper.



Plastic block with clock built in.

Clock table lamp.

6. Buff.
7. Drill hole.
8. Cut out to correct size.
9. Assemble clock.

• ***Clock table lamp.***

Tool List

1. Pencil
2. Try square
3. Circle saw
4. Machine sander
5. Drill press
6. Twist drills: ⅛″, ⅜″, ¾″, and 1″
7. Cutter to be used on drill press
8. Carving tools
9. Gluing equipment
10. Dyeing equipment
11. Vise

Bill of Materials in Inches

1—1¾ x 5 x 7	clear, for clock
1—¼ x 3 x 8	black, for top of box
1—¼ x 2½ x 4¾	black, for bottom of box
2—¼ x 2½ x 5	black, for sides of box
2—¼ x 2½ x 2½	black, for ends of box
4—¼ x 1 x 1	black, for feet
1—1¼ x 1¼ x 4	black, for upright

Procedure

A. Box

1. Lay out.
2. Saw out.
3. Drill holes in top with ¾″ twist drill.
4. Sand saw marks out on machine sander.
5. Scrape on edge of sides and ends with plane iron, and hand sand.
6. Glue up sides and ends.
7. Hand sand and buff edges of top.
8. Glue top to sides and ends.
9. Drill holes in bottom.
10. Sand on machine sander.
11. Drill hole for switch.
12. Assemble small light fixtures in box. Small bulb must be used in box. Size of Christmas tree lights is suggested.
13. Fasten bottom on with screws.

B. Feet

1. Lay out.
2. Saw out.
3. Sand saw marks out on machine sander.
4. Shape on machine sander.

5. Hand sand, using fine sandpaper.
6. Buff.
7. Glue feet on edges of ends and sides.

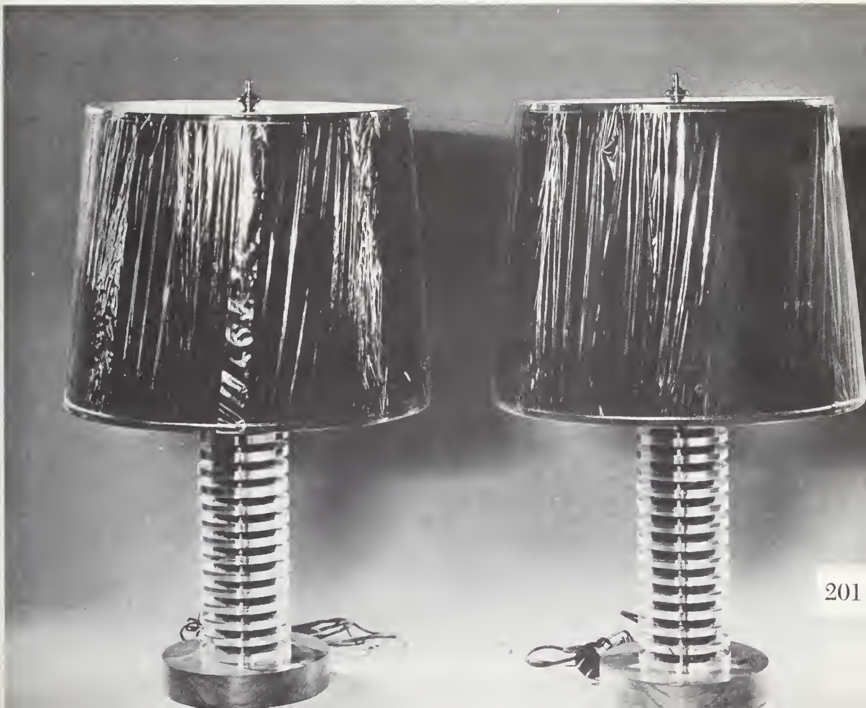
C. Clear Block

1. Lay out.
2. Saw out.
3. Drill hole for clock, using 1″ twist drill.
4. Cut out to correct size, using cutter on the drill press.
5. Drill hole for lamp cord, using ⅜″ twist drill.
6. Carve design.
7. Apply dye.
8. Apply plaster of paris and allow to dry.
9. Scrape with plane iron.
10. Sand by hand, using fine sandpaper.
11. Buff.
12. Assemble clock.
13. Glue onto box.

D. Upright

1. Lay out.
2. Saw out.
3. Shape on machine sander.
4. Sand by hand, using fine sandpaper.
5. Buff.
6. Drill ⅜″ hole with twist drill.
7. Fasten lamp nipple in top.
8. Glue onto clear.

Wood and plastic lamp.



- ***Wood and plastic lamps.***

Bill of Materials in Inches

1—1¼ x 5 x 5	walnut wood, for base
14—¼ x 2¼ disc	clear plastic, for upright
13—¼ x 1¼ disc	black plastic, for upright

Tool List

1. Compass
2. Band saw
3. Machine sander
4. Drill press
5. ⅜″ twist drill
6. Gluing equipment
7. Finish brush
8. Buffer.

Procedure

1. Lay out.
2. Saw out.
3. Sand saw marks out on machine sander.
4. Sand by hand, using fine sandpaper.
5. Buff.
6. Drill holes. NOTE: Each hole must be in center.
7. Finish wood with lacquer.
8. Fasten lamp nipple in top parts.
9. Glue up.

- ***Carved plaques.***

Tool List

1. Pencil
2. Ruler
3. Circle saw
4. Machine sander
5. Plane iron
6. Vise

Plaques. (¼ x 5 x 8, or 6 x 9), clear, for shallow carving.

7. Buffer
8. Carving tools
9. Dyeing equipment
10. Engraving machine

Procedure

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape with plane iron.
5. Hand sand.
6. Buff.
7. Carve designs.
8. Apply dye.
9. Apply plaster of paris.
10. Engrave lettering.
11. Polish.
12. Fasten on hanger.

• *Combination serving table and end table with lamp and tray.*

Bill of Materials in Inches (use clear)

1—½ x 16 x 20	for top
2—⅜ x 3 x 42	for legs
2—⅜ x 3 x 18	for upright braces
1—⅜ x 3 x 14	for bottom brace
2—¼ x 2 x 16 sides	for tray
2—¼ x 2 x 12 ends	for tray
4—½ x 1 x 1 feet	for tray
2—⅜ x 4 x 8 upright sides	for lamp
2—⅜ x 3 x 8 ends	
1—⅜ x 3 x 4 top	for lamp
1—1 x 3 x 4 base	for lamp

Tool List

1. Framing square
2. Yardstick
3. Circle saw
4. Band saw
5. Drill press
6. ⅜″ twist drill
7. Vise
8. Plane iron
9. Buffer

Combination serving table and end table with lamp and tray.

10. Gluing equipment
11. Compass
12. Jig to bend legs
13. ½″ twist drill
14. Oven, hot pads or gloves

Procedure

1. Lay out.
2. Saw out.
3. Sand on machine sander.
4. Scrape with plane iron.
5. Hand sand.
6. Buff.
7. Drill holes in legs and bottom brace.
8. Drill hole and assemble nipple for lamp.
9. Heat legs and place in jig.
10. Glue up.

• ***Napkin holder.***

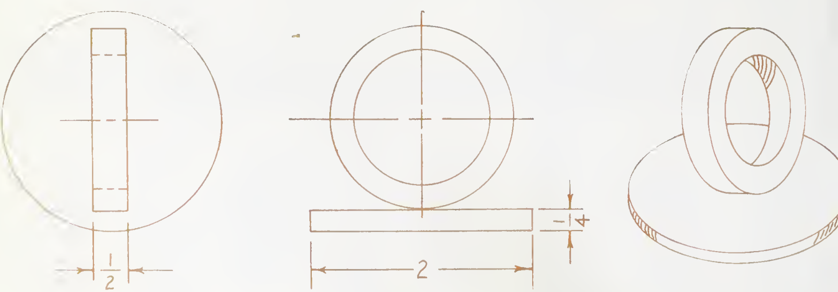
Often a plastic item found around the home can be used as a mold to cast liquid plastic. Spray-can tops of different sizes and shapes, food containers, and bottles are all good examples. The napkin holder described here is made with a spray-can top.

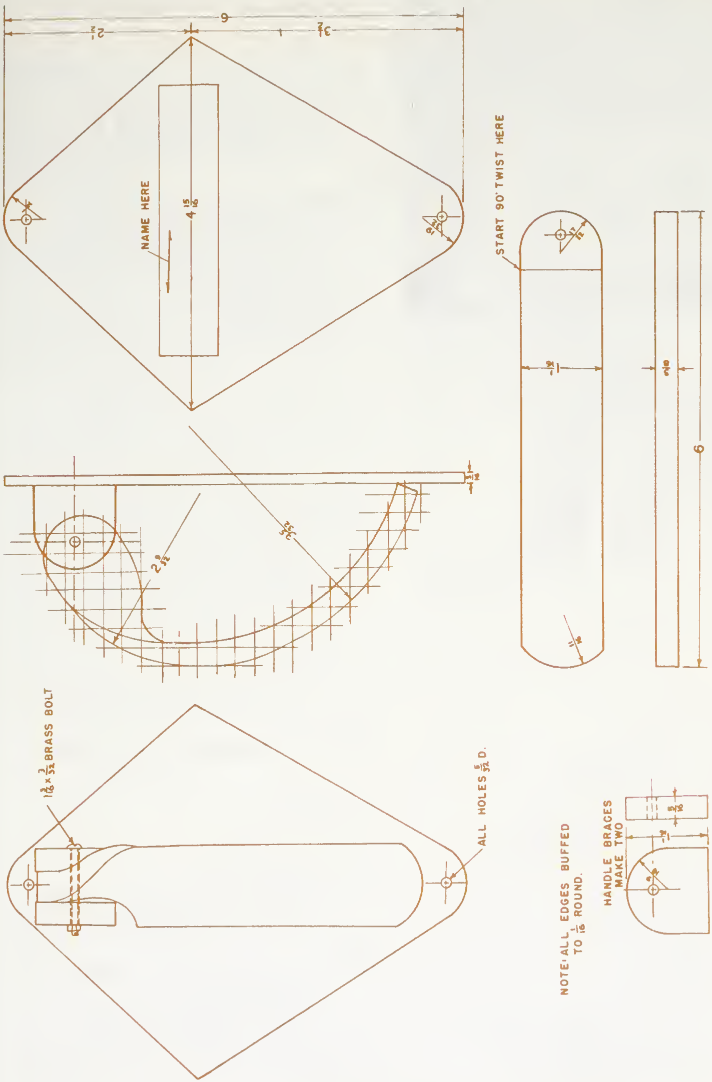
Napkin ring made by using a spray-can top as a mold.

Procedure

1. Select a spray-can top with a center section.
2. Clean the spray-can top and dry it with a paper towel. Be sure that the mold is clean and dry.
3. Mix 1 ounce of plastic resin and the desired color of dye. Other items may then be added—glitter, chips of marble, or metal shavings from the metal lathe or drill press. A paper cup or a squeeze bottle can be used to mix the resin and the dye.
4. Add 10 drops of catalyst and stir into the resin.
5. Pour the mixed resin into the mold and allow to cure.
6. Remove the ring from the mold by pressing the top of the mold with your hands.
7. The base for the napkin ring is made by selecting a spray-can top that does not have a center section. Follow the same procedure for mixing the resin and casting.
8. Cement the ring to the base.

Drawings for napkin holder.





Door handle drawing.

Door knocker.

• ***Door knocker.***

Bill of Materials in Inches

1—$\frac{3}{16}$ x $4\frac{15}{16}$ x 6	white	for back
1—$\frac{3}{8}$ x $1\frac{1}{16}$ x 6	clear	for handle
2—$\frac{5}{16}$ x $1\frac{1}{16}$ x $1\frac{1}{16}$	clear	for brace
1—$\frac{3}{32}$ brass bolt		

Tool List

1. Pencil
2. Compass
3. Straightedge
4. Circle saw
5. Machine sander
6. Engraving machine
7. Drill press
8. $\frac{3}{32}''$ twist drill
9. Screwdriver
10. Pliers
11. Plane iron
12. Vise
13. Oven, hot pads, gloves
14. Gluing equipment
15. Jig for handle

Procedure

A. Back

1. Lay out.
2. Saw out.
3. Engrave name.
4. Apply paint and allow to dry.
5. Buff off excess paint.
6. Sand on machine sander.
7. Scrape with plane iron.
8. Hand sand.
9. Buff.
10. Drill holes.

B. Handle

1. Lay out.
2. Saw out.
3. Sand out saw chips on machine sander.
4. Shape ends round on machine sander.
5. Scrape with plane iron.
6. Hand sand.
7. Buff.
8. Heat in oven.
9. Place in jig and allow to cool.
10. Drill hole for brass bolt.

C. Braces

1. Lay out.
2. Saw out.
3. Shape on machine sander.
4. Hand sand all except bottom.
5. Buff all except bottom.
6. Drill holes.
7. Glue braces on back.
8. Allow glue to set, and assemble.

- ***Chair mat for carpet protection.***

Procedure

1. Select the desired color and texture of plastic. Acrylite plastics come in several different colors and textures.
2. Mark off the desired design. If a pattern is needed, it can be made from wrapping paper.
3. Saw out the design. Use the band saw to cut curved lines and the circle saw for straight lines. Observe all safety precautions when using the saws.
4. Shape and smooth the edges with a router, using a cutter that will give a rounded edge. Clamp the plastic firmly to the worktable top. Take care not to scar the plastic by cleaning the worktable and using smooth surface clamps. Set the router to cut only a small portion at a time.
5. Hand sand the edges and buff.

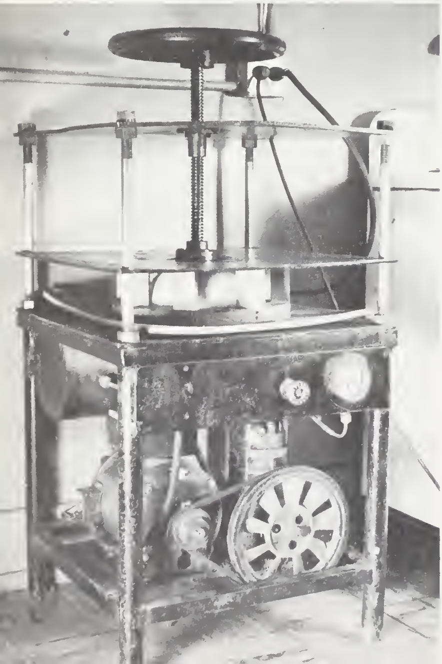
AMERICAN CYANAMID CO.

Using a router to shape and smooth the edge of a plastic chair mat.

20 FORMING ACRYLIC PLASTICS

To make a plastic forming press in the industrial arts shop adds to knowledge and skills and also offers the opportunity to form plastic in the manner of industry. The forming press is a machine made to hold a die or mold air tight on hot plastic and, with the use of air pressure, force the hot plastic into the shape of the die. After the press is made, the making of the dies and molds will offer a wide range of practical, valuable experience.

Plastic forming press.

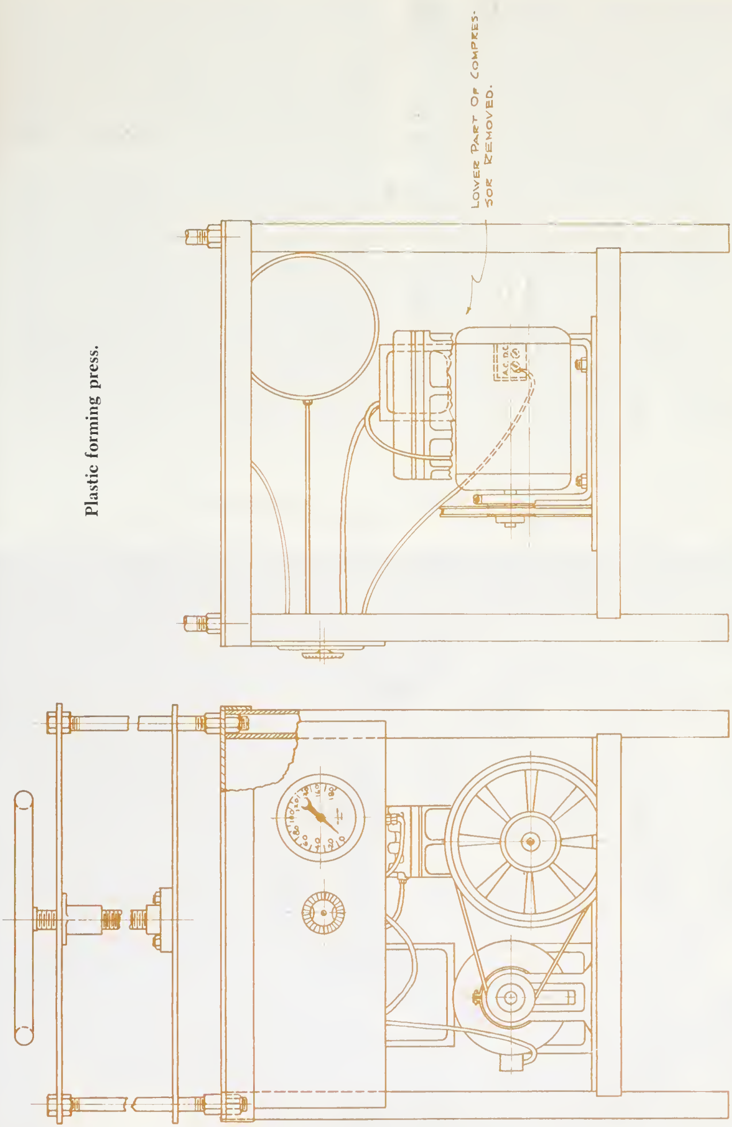


The following materials are used to make the forming press:

An air compressor and tank with 120 psi capacity are mounted on a platform with a piece of ⅜ inch metal 22 x 22 inches, mounted on top. To this compressor attach a ¼ hp motor. The tank has a gauge allowing pressure up to 150 pounds. This control insures against explosion. Tubing is run from the compressor to the tank and from the tank to the edge of the metal. There a control valve turns the air on and off and regulates its flow. Then the tubing is run from the edge of the metal to the center and up through. The top of the metal is covered with a ½ inch rubber seal or gasket.

The upper part of the press is made as follows:

One inch holes are drilled in the corners of the rubber and metal for rods. Four pieces of 1-inch metal rods are cut, threaded on both ends, and fastened in these holes, with a check nut on the underside of the metal and one on the top of the rubber. It is important to set the rods at a right angle so as to permit easy



Plastic forming press.

operation of the press. Then another piece of metal, ⅜ x 22 x 22 inches, is cut and holes drilled in the corners to fit loosely over the upright rods. A third piece of metal, ⅜ x 22 x 22 inches, is also cut with holes drilled in the corners for the metal rods. This is held at the top, with check nuts above and below. A screw from an old bench vise is fitted to run down the center of the third, or top, piece with the bottom of the screw fitted to the movable piece of metal. A wheel is fastened on the upper end of the vise screw. With this attachment the loose piece can be moved up and down by turning the wheel. The top of the third, or upper, piece of metal is reinforced with angle iron.

The dimensions of the forming press may vary with individual shop needs.

After the forming press is made ready for use, the number of different dies made to be used in it will determine how valuable the machine becomes. It is interesting to work out dies to form heated plastic. For example, if a set of buffet plates is wanted, the design, size, and shape desired by the individual can be created.

Many of us will have a tendency to make projects for which someone else has worked out a die, if not encouraged to give some thought and work to designing our own. The desire for knowledge on how items in plastic are made, as well as the desire to develop skills in working with plastic, is the real incentive for us to make our own dies. Even if you make a die that will not give pleasing results, you will learn much about forming plastic. To know that which *cannot* be done is often as valuable as to know what *can* be accomplished.

Several different dies are illustrated and discussed in this unit to give methods and principles on how they are made. After making and using these dies you will be capable of making others, or improve on some. The procedure to follow in making a die is determined by the size and shape of the plastic item.

• *Buffet plate die.*

Bill of Material for the Die in Inches

2—1 x 14 x 14	Masonite or Formica
1—⅛ x ½ x 37	band iron
1—⅛ x 1¼ x 10½	band iron
3—⅛ x 1 x 4¼	band iron

Procedure

1. Saw two 14 inch discs from the Masonite or Formica and plywood, using a metal cutting blade on the band saw. Formica will dull a wood cutting band saw blade.

2. Mount a faceplate on the side of the plywood opposite the Formica or Masonite.

3. Turn the outer edge smooth and cut a groove ⅛ inch in depth, 1⅝ inches from center. This will make a groove for the first ring of band iron. This ring is to make a place for the glass or cup in the buffet plate.

4. Take the first piece of Formica and plywood off the lathe and remove the faceplate.

5. Fasten faceplate to the second piece of Formica and plywood; turn the outer edge round.

6. Cut a groove ¼ inch in depth and 1½ inches from the outer edge. This groove is for the longer piece of band iron.

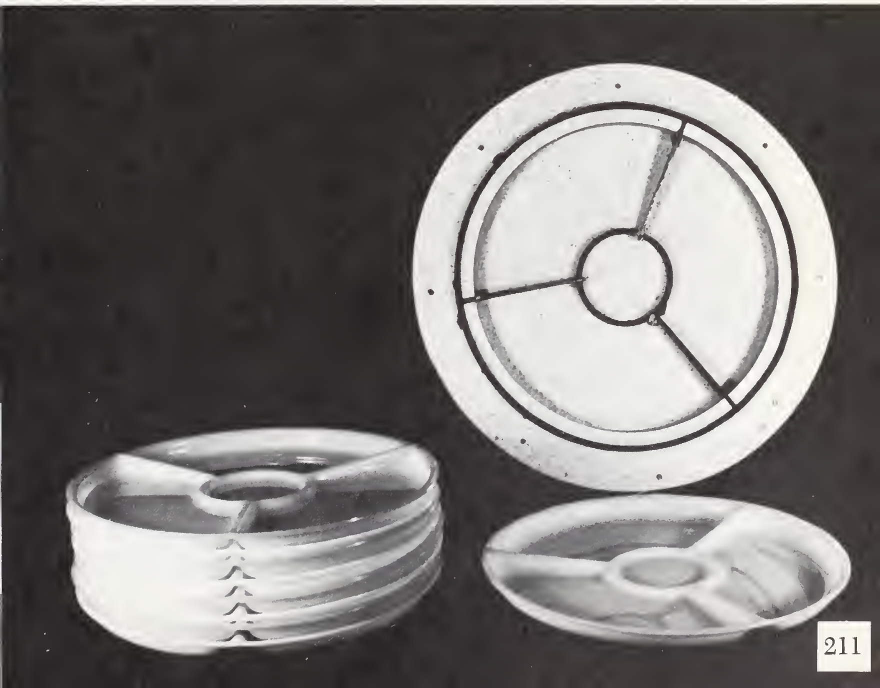
7. Measure ½ inch from the groove toward the center and cut all the way through the Formica and plywood. This will leave a ring with an outer edge 14 inches in diameter and an inner edge 10 inches in diameter. Divide the inner circumference into three equal parts. At these measurements, cut a slot into the ring for one end of the cross section of the band iron.

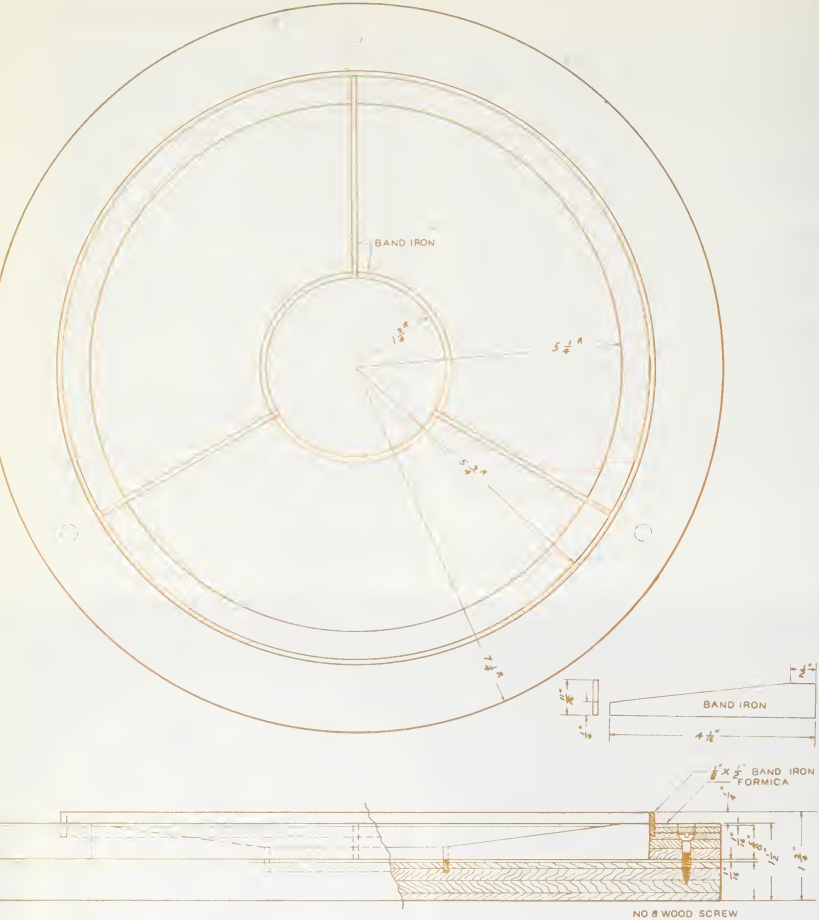
8. Divide the band iron for the center ring into three equal parts, and cut a groove ⅛ x 1 inches. These grooves are for the other end of the cross sections to be mounted.

9. Fasten the ring of Formica and plywood to the first Formica-plywood disc, using nails and glue.

10. Bend the band iron and assemble in the groove. Place the cross sections of band iron in grooves. File smooth all rough parts of the metal.

Buffet plates and the die used for forming.





Buffet plate die.

• ***Using the die to make an eleven-inch buffet plate.***

Procedure

1. Cut out a 12 inch disc, or a 12 inch square, of ⅛ inch plastic.
2. Turn on motor of the forming press and build up from 60 to 100 pounds of air pressure.
3. Heat the plastic in the oven at a temperature of 325° F. for 20 minutes.
4. Place the hot plastic on the

rubber part of the forming press. Place the die on the hot plastic and tighten down air tight, by using the wheel.

5. Open the air valve; the air will blow the plastic into all parts of the die.

6. The buffet plate is now formed; however, leave it in the forming press for 5 minutes to allow the plastic to cool. If the plastic is taken out before it is cool, the plate will be uneven.

7. To take the die and plastic out of the forming press, turn the air valve off and release by turning the wheel on top portion of the forming press.

8. Saw the waste portions of the buffet plate off, using the band saw.

9. Sand the edges smooth on the disc sander. To assure the plate being round, sand to the rim mark all the way around.

10. Sand the edges by hand, using fine sandpaper, and buff the plastic to a high polish.

• ***Making a punch bowl mold.***

Bill of Material for a 10 inch Punch Bowl Mold in Inches

2—¾ x 13 x 13	plywood
1—¼ x 13 x 13	Masonite
8—1½ x 2¾	wood dowels
1—¼ x 13	crepe rubber

Procedure

1. From the plywood, saw two rings with an outside diameter of 13 inches and an inside diameter of 8½ inches.

2. From the crepe rubber, saw a ring with an outside diameter of 13 inches and an inside diameter of 8 inches.

3. Saw a disc 13 inches in diameter from the Masonite.

4. Fasten the two rings of plywood together with nails; nail the wood dowels equally spaced on the rings.

5. Nail the Masonite to the wood dowels.

6. Glue the crepe rubber ring on the bottom side of the plywood rings. Epoxy-cement is good for this. The rubber is to help seal the mold air tight while being used to make the bowl. If it is desirable not to use the rubber, a groove is cut in the wood disc on the lathe and band iron used instead to seal the mold air tight.

• ***Making the punch bowl with the mold.***

Procedure

1. Saw a 12 inch disc, or a 12 inch square, of plastic 3⁄16 inch in thickness.

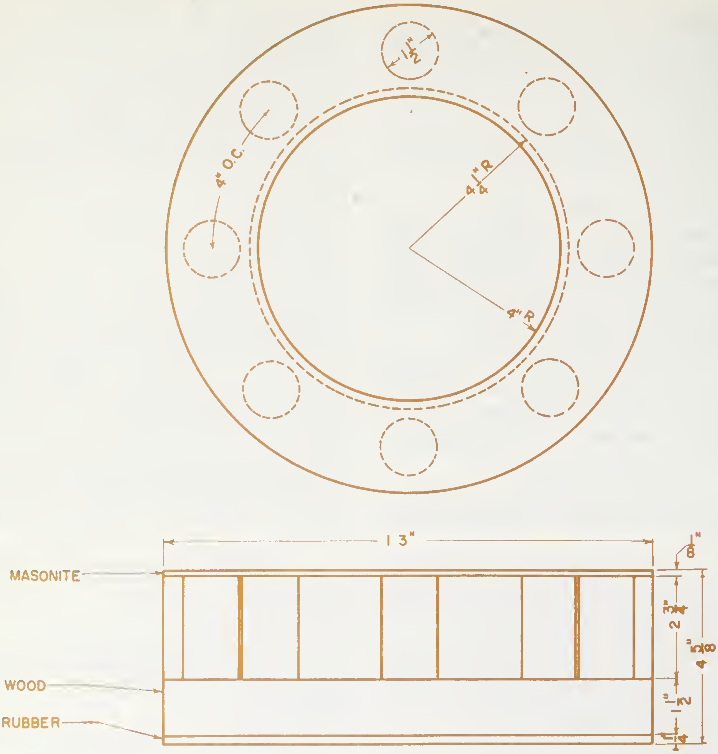
2. Heat the plastic in the oven at 325° F. for 20 minutes.

3. Turn on the motor of the forming press and build up from 60 to 90 pounds of air pressure.

4. Place the hot plastic on the rubber section of the forming press and then place the mold on the hot plastic.

5. Tighten the mold down air tight by turning the wheel.

6. Open the air control valve and allow enough air in to blow the bowl up to the Masonite and form the desired size bottom. Then cut air off. If the air is not



Mold for punch bowl.

controlled it will blow the plastic between the wood dowels and tear a hole in it. Also be careful not to allow the sides to be blown so large that the bowl will not come out of the mold. A good feature for this mold is that you can see the bowl being blown up, while a feature against it is that the air must be controlled until the plastic is cool.

7. After the plastic is cool, it is taken out of the forming press and mold.

8. Saw the waste part off by using the band saw.

9. Sand the edge smooth, using the disc sander.

10. Hand sand the edges and buff to a high polish.

- ***Dies to make dishes.***

Two methods are illustrated and discussed here on how to

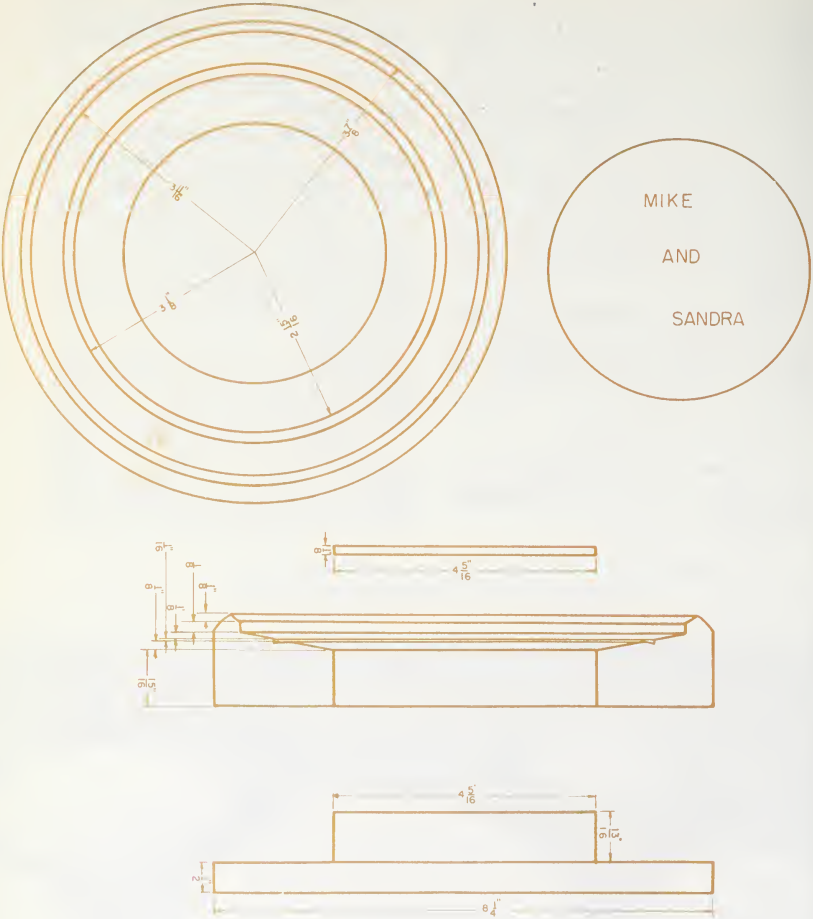
make and use dies to form dishes. One method is to make a die that is used for personal needs, and with a small change can be used by others for a different personal need, such as to form a picnic plate with one's name or initials on the bottom, or a camp plate bearing the name of the camp. Others make dies to form their club emblem on the bottom of the plates.

The second method illustrated and discussed is the making of dies to form dishes without the personal additions.

Picnic plate die procedure

1. Saw out a wood disc 1½ x 8½ inches, using close-grained hardwood.
2. Fasten a faceplate on the disc and assemble it on the wood lathe.
3. Turn the circumference true and smooth.
4. Cut the desired shape of the plate into the wood disc, using wood turning tools and lathe.
5. With coarse, medium, and fine sandpaper, sand smooth the surface to be contacted by the plastic. The bottom or center section is not to be sanded; this is to be cut out.
6. While the lathe is running, apply buffing compound on the parts that have been sanded.
7. Polish the surface by using a paper towel or a cotton cloth, while the lathe is running. This method of polishing fills the pores

Plastic dishes made on the plastic forming press.



of the wood to give a hard, smooth finish. Shellac or varnish should not be used because they would come off on the hot plastic.

8. Cut the center section out with the parting tool. The lathe is set to run at a slow speed and care is taken as the parting tool goes through the wood. This ring portion is now taken off of the lathe. The center portion left on is waste material.

Vegetable bowl, picnic plate, and dies used for forming.

9. Cut a wood disc $\frac{13}{16}$ x $4\frac{5}{16}$ inches; this disc is to fit into the die ring where the center was cut out.

10. Cut a disc of plywood $\frac{3}{4}$ x $8\frac{1}{4}$ inches; the $\frac{13}{16}$ x $4\frac{5}{16}$ inch disc is fastened onto the plywood disc, in the center.

11. Cut a disc of Masonite $\frac{1}{8}$ x $4\frac{5}{16}$ inches. This is used on top of the wood disc cut out for the center section.

12. On the Masonite, engrave the name or emblem. If clear plastic is used, the name or emblem is engraved reading right. On colored plastic, a reverse image is used.

A new Masonite part can be made for others who use this die with a different name or emblem.

Procedure for Making a Picnic Plate with the Die

1. Lay out and saw a piece of plastic $\frac{3}{16}$ x 9 x 9 inches.

2. Heat the plastic in the oven at a temperature 325° F. for 20 minutes. While the plastic is heating, turn the motor on the forming press to build up to 100 pounds of air pressure.

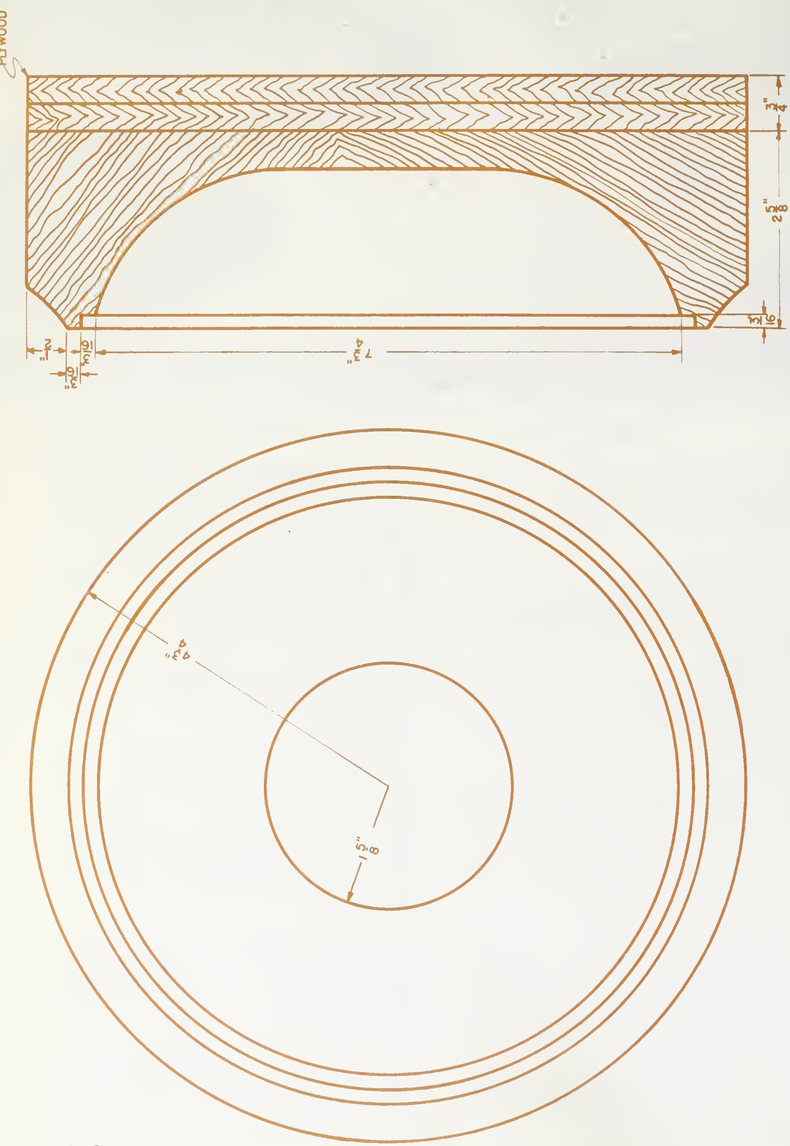
3. Place the hot plastic in the forming press, and place the die on top of the hot plastic.

4. Tighten down the die by turning the wheel.

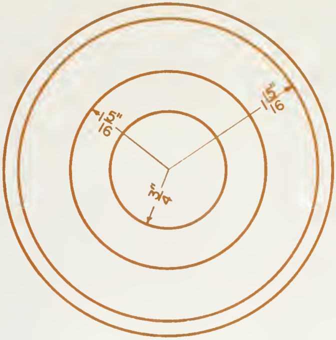
5. Open the air control valve on the forming press. Allow the plastic and die to stay in for five minutes. This gives ample time for cooling. If the plastic is taken out before it is cool, the plate will be uneven.

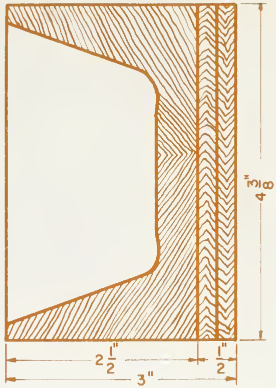
6. Cut off waste with the band saw. The die forms a rim around the edge of the plate to enable accurate sawing.

7. Sand the saw chips out on the disc sander. Again the die has formed a rim to enable the sanding to be accurate.

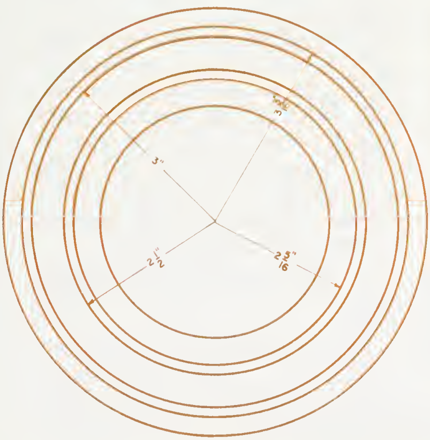


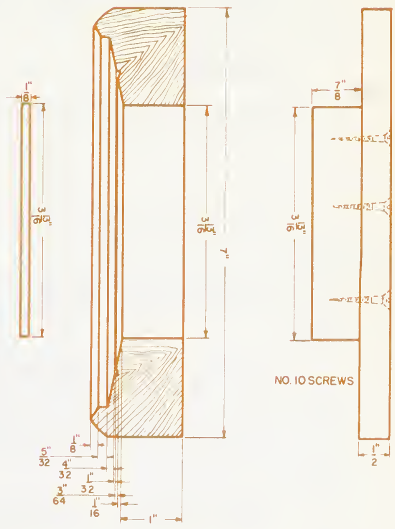
Vegetable bowl die.

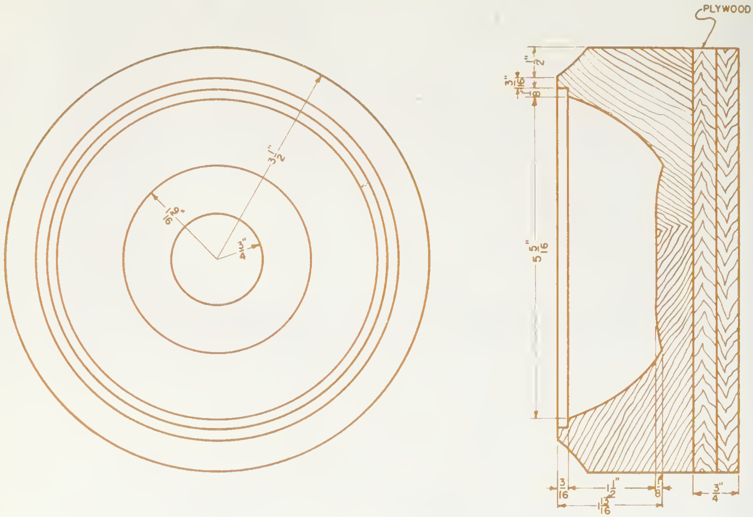

1 5/16"
1 5/16"
3/4"


4 3/8"
2 1/2"
1/2"
3"


MIKE
AND
SANDRA


3"
2 1/2"
2 5/16"


1/8"
3 13/16"
7"
7/8"
NO. 10 SCREWS
1/2"
5/32
4/32
3/64
1/32
1/16
1"



8. Hand sand the edges and buff to a high polish.

- ***Small bowl die.***

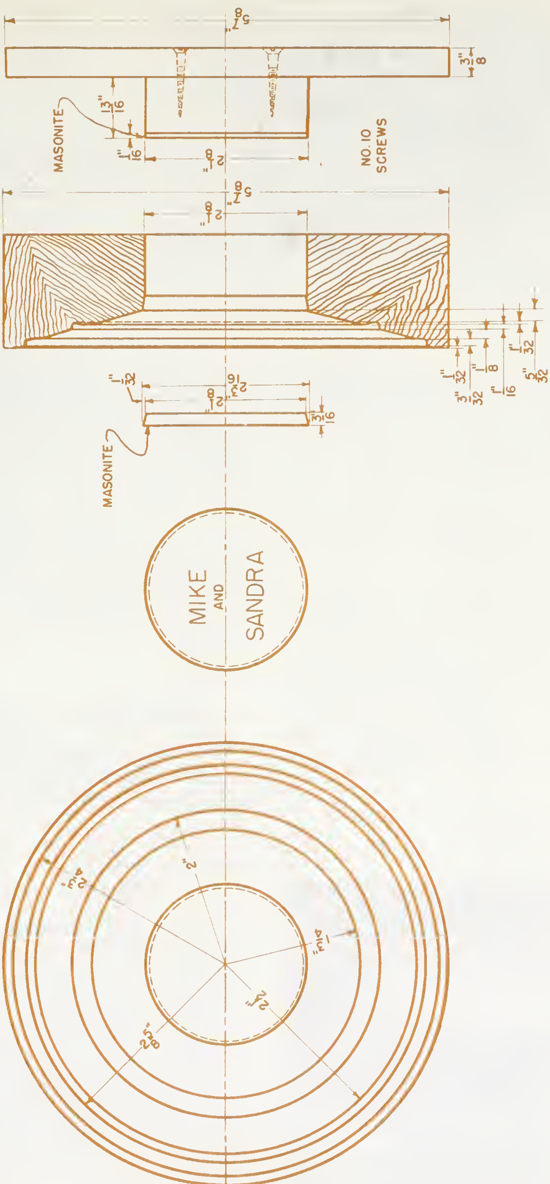
This die is not used to form personal emblems or names.

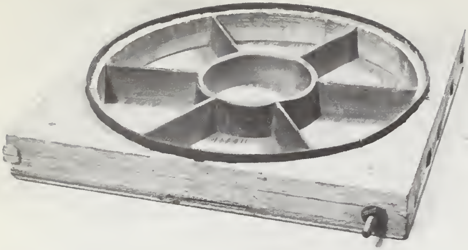
Procedure

1. Lay out and saw out a close-grained, hardwood disc 2½ x 7 inches.
2. Assemble the wood disc on the lathe and turn out the desired shape.
3. Sand the surface of the die smooth. This is done by first using coarse, then medium, and then fine sandpaper. Sand the surface smooth to form a bowl without marks from the die.
4. Apply buffing compound. This is done while the lathe is running.
5. Polish by using a paper towel or a cotton cloth, while the lathe is running. This method is used to fill the pores of the wood and to give a hard and smooth finish. Do not use shellac or varnish on the die because they would come off on the hot plastic.
6. Take the die off the lathe and cut a disc of plywood ¾ x 7 inches. This is glued to the bottom of the die to strengthen it.

To use this die, follow the same procedure as for the the Picnic Plate.

Picture frames, hub caps, tail-light covers, ceiling light shade, ladies' handbags, and cake covers are suggested problem-solving


MASONITE
NO. 10 SCREWS
MASONITE
MIKE
AND
SANDRA



Mold for a Lazy Susan.

projects for the plastic forming press. Each requires designing and making a die as well as forming and making the item. The many choices lend themselves to individual needs and wants, thus making it practical for each pupil to make his own die.

Points to keep in mind when designing and making a die are: (1) The shapes plastic may be formed into by using the forming press; (2) methods of sealing air tight; (3) material to use for smoothness and strength; (4) thickness of plastic required; (5) avoid a die with sharp corners that will tear the plastic.

A suggestion for economy when making a die to form a *picture frame* is to make a 7 x 9 inch frame within an 8 x 10 inch frame, and a 5 x 7 inch frame within a 7 x 9 inch frame, thus making three picture frames with one operation and using only one piece of plastic.

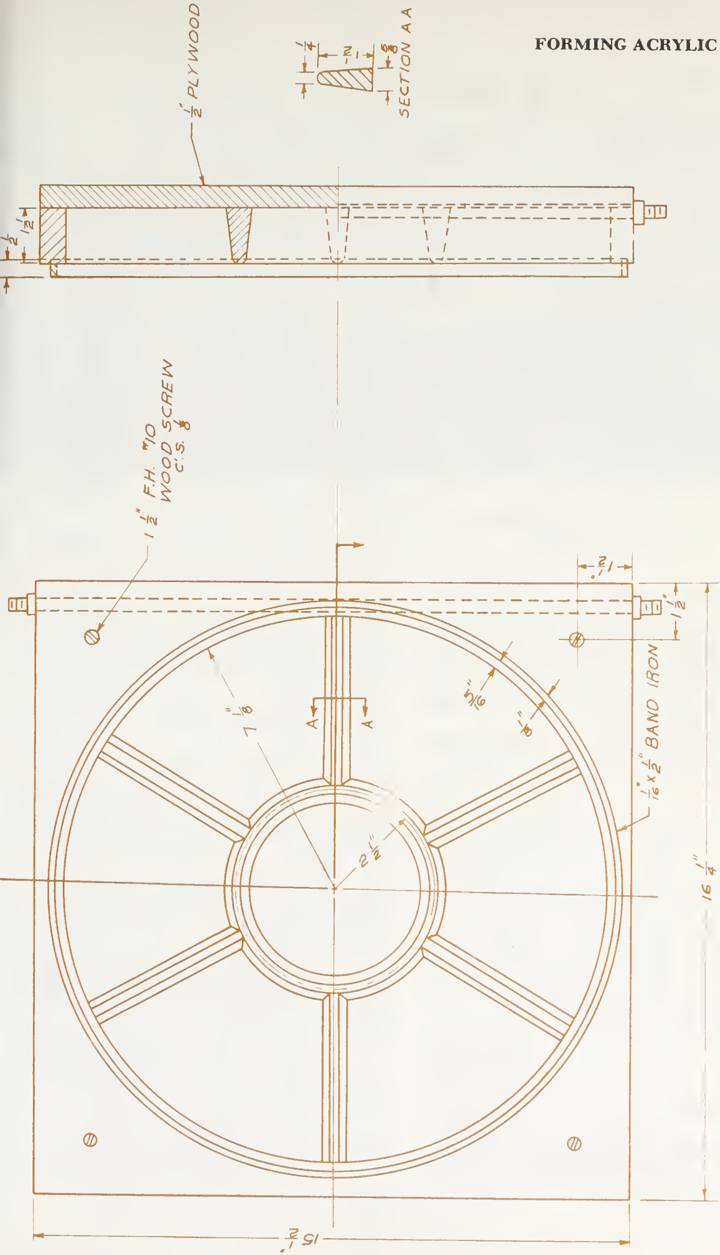
Plastic Lazy Susan.

- ***Seven-section Lazy Susan.***

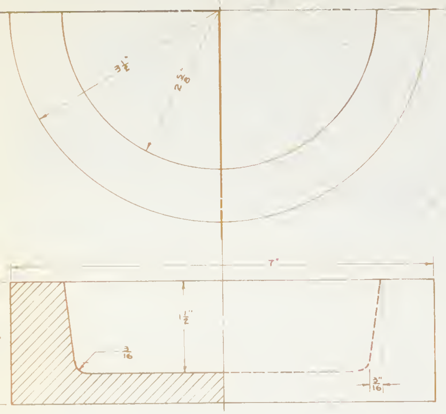
The lazy Susan illustrated is 15 inches in diameter. It may be made larger or smaller as desired.

Procedure for Making Top Section Mold

1. Cut out piece of wood 2 inches thick, 16 inches to 18 inches square, depending on size of lazy Susan desired.
2. Assemble bolts through the ends, or cut a groove across the end and glue a strip of wood in the groove. This prevents the mold from pulling apart under pressure.

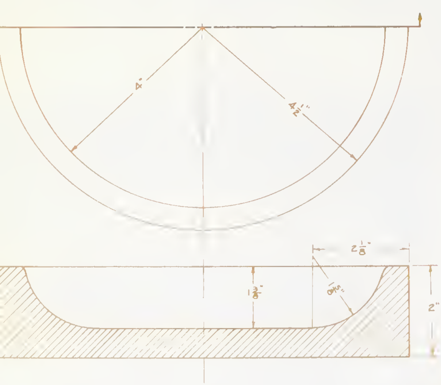


A—Drawing of a Lazy Susan Mold.



B—Mold to form upper section of a Lazy Susan base.

3. Mark circle 13 inches to 15 inches in diameter.
4. With the drill press, drill a hole in the section to be cut out.
5. Assemble in the jig saw and cut out the circle.
6. Smooth edges by filing and sanding.

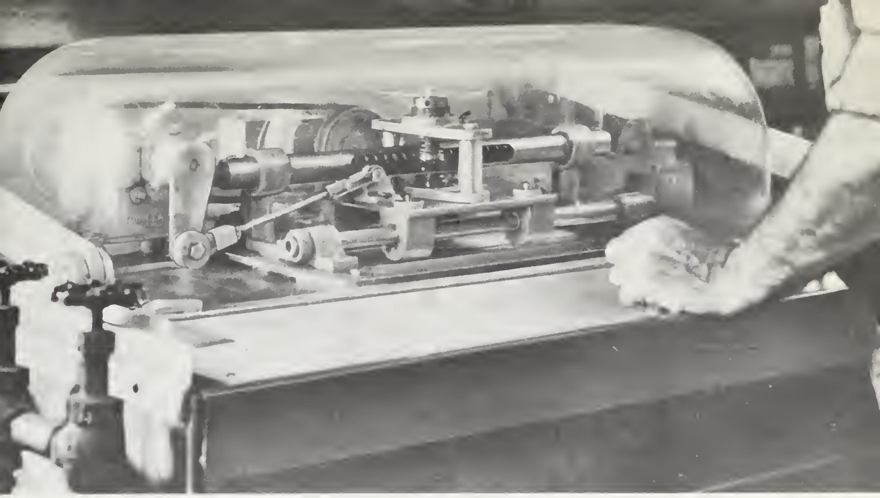


7. Using glue and nails, fasten the rim portion of the mold onto a smooth piece of wood.
8. On the lathe cut the wood rim ½ inch x 2 inches x 6 inches.
9. Smooth the rim, making a slope inside and outside so the top of the rim will be ¼ inch thick.
10. Glue the rim in the center of the mold.
11. Divide the circle into 6 equal parts. Make wedge-shaped pieces of wood 2 inches high, sloping from ½ inch at bottom to ¼ inch at top. Smaller measurement at top is needed for the mold release.
12. Cut wedge-shaped pieces to proper length and fit them into the mold.
13. Using a router, cut a groove around the top 1 inch from the outer circle.
14. Fasten a strip of band iron into the groove.

Procedure for Using Mold

1. Saw a disc of plastic 1 inch larger in diameter than the band iron rim.
2. Heat the plastic in a preheated oven at 300 to 350 degrees F. until flexible.
3. Place the hot plastic and the mold in the forming press and make it air tight.
4. Open the air valve.
5. Leave plastic in the forming press until cool.

C—Mold to form lower section of a Lazy Susan base.



Plexiglas cover for a mechanical display.

6. Remove plastic from the forming press and mold.
7. Cut off waste portions with a band saw.
8. Sand edges with a disc sander.
9. Hand sand with fine sandpaper.
10. Buff edges to a high polish.

Procedure for Making Base Molds

Top Section of Base:

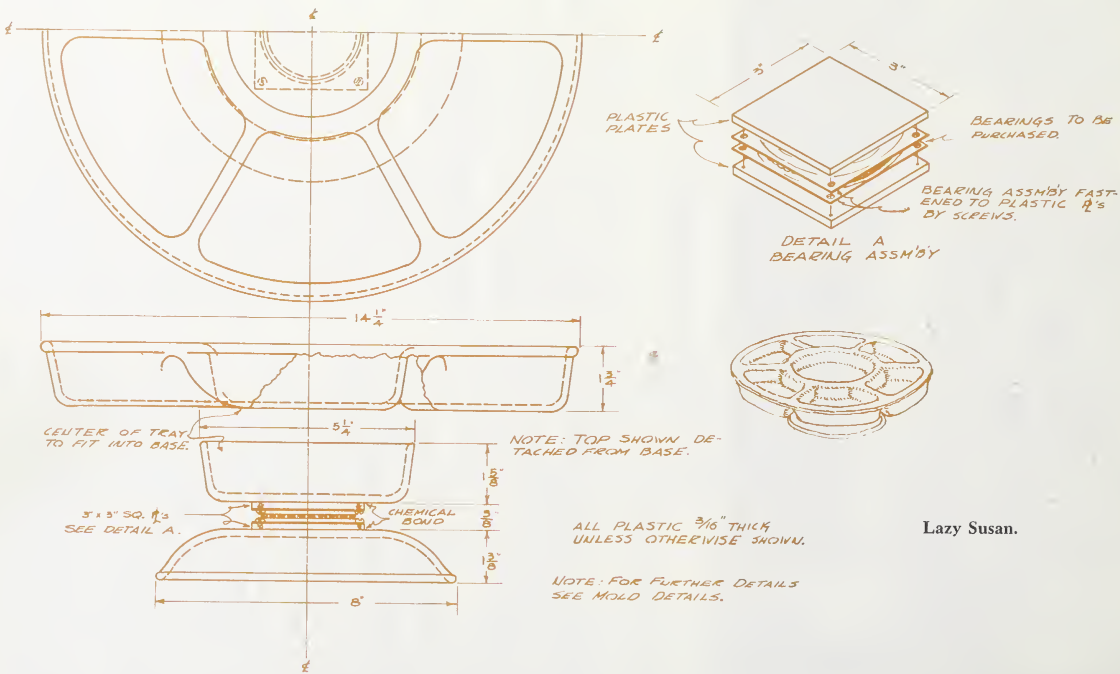
1. Cut out a hardwood disc 2″ x 7″ (approx.).
2. Assemble on the lathe.
3. Cut wood to form a bowl that will fit into the center rim of the Lazy Susan.
4. Sand the inside smooth.
5. Apply a buffing compound to the wood and shine with a cloth or paper towel.
6. Apply paraffin to the wood and shine with a cloth or paper towel.
7. Remove from the lathe and faceplate.

Bottom Section of Base:

1. Cut out a hardwood disc 2″ x 10″ (approx.).
2. Assemble on the lathe.
3. Cut wood to form a bowl of desired shape and size.
4. Sand the inside smooth.
5. Apply buffing compound and polish with cloth or paper towel as the lathe runs.
6. Apply paraffin and polish with cloth or paper towel as the lathe runs.

Procedure for Using Base Molds

1. Saw out plastic pieces the same sizes as the molds.
2. Heat in a pre-heated oven


14 1/4"
3/4"
5 1/4"
1 5/8"
3/8"
1 3/8"
8"
CENTER OF TRAY TO FIT INTO BASE.
NOTE: TOP SHOWN DETACHED FROM BASE.
3" x 3" SQ. ℄'s SEE DETAIL A.
CHEMICAL BOND
ALL PLASTIC 3/16" THICK UNLESS OTHERWISE SHOWN.
NOTE: FOR FURTHER DETAILS SEE MOLD DETAILS.
PLASTIC PLATES
3"
3"
BEARINGS TO BE PURCHASED.
BEARING ASSM'BY FASTENED TO PLASTIC ℄'s BY SCREWS.
DETAIL A
BEARING ASSM'BY

Lazy Susan.

300 to 350 degrees F. until flexible.

3. Place the hot plastic and the mold in the forming press and make it air tight.

4. Open the air valve.

5. Allow the plastic to cool and then remove it from the press and mold.

6. Cut off waste portions with a band saw.

7. Disc sand the edges smooth.

8. Hand sand the edges with fine sandpaper.

9. Buff the edges to a high polish.

Assembling Procedure

1. Saw two pieces of plastic 3″ x 3″.

2. Disc sand the edges smooth.

3. Hand sand with fine sandpaper.

4. Buff the edges to a high polish.

5. Fasten the two pieces onto the face of 3″ x 3″ ball bearing. This gives level gluing surface and a plastic-to-plastic glue joint.

6. Glue the ball bearings between the two sections of the base.

7. Allow glue to set and place the lazy Susan section onto the base. The small bowl part of the base fits into the center rim.

Questions on Forming

1. What is the forming press?

2. What is the real incentive for making one's own dies?

3. What materials are needed to make a forming press?

4. What will determine how valuable the forming press is to you?

5. List the materials needed to make a buffet plate die.

6. Why is a metal cutting band saw blade used to saw Formica?

7. How much air pressure is needed to form a buffet plate?

8. How long should the plastic for a buffet plate be heated?

9. How long should the plastic be left in the forming press?

10. What will happen if the plastic is taken out of the forming press before it cools?

11. Why should shellac or varnish not be used on wood dies?

12. What kind of wood is used to make dies?

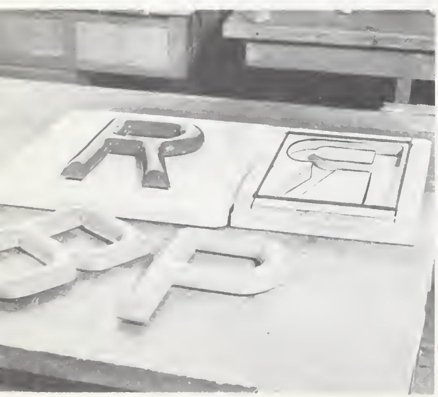
13. What procedure is followed to get a smooth surface on a wood die?

21 MAKING SIGNS OF PLASTIC

Signs made of acrylic plastic—Plexiglas or Lucite—are one of the major types in use today. In industrial arts, we learn the making of plastic signs just as we learn signmaking in commercial arts classes.

There are four major types of plastic signs, three of which may be learned in the industrial arts shop: (1) signs made of individual letters to be glued on the outside walls of a building; (2) signs made by engraving letters on plastic—used on the inside, as nameplates, door plates, and direction signs; (3) signs made by individual letters glued on plastic, for the same purposes as engraved signs.

Plastic letters and a die used to form the letter "R."



Equipment and procedures for making the signs mentioned above are discussed in this unit.

• ***Equipment for signs made simply of individual letters.***

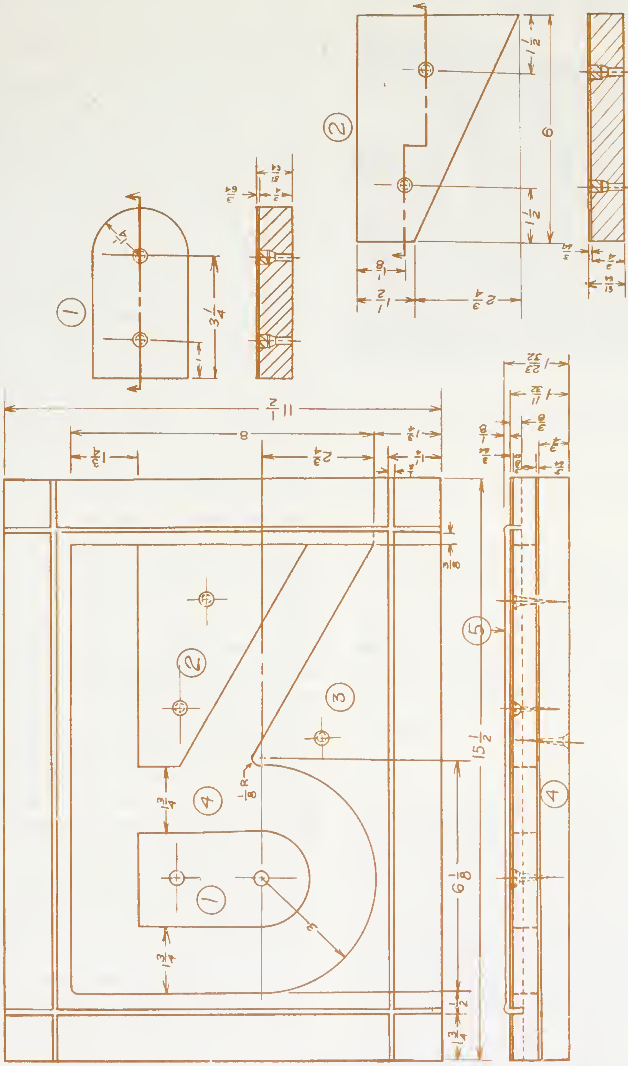
1. Plastic forming press.
2. Dies to form individual letters.
3. Oven for heating plastic.
4. Circle saw.
5. Band saw.
6. Jig or scroll saw.
7. Disc and belt sander.
8. Gluing equipment.
9. Drill press.
10. Cabinet file.
11. Carving drill.

The making and use of dies for 12-inch letters follows, to give general procedures. However, for a different size and style, the same method applies.

Materials consist of two pieces of Formica and plywood 1 x 11 x 15 inches. The size will vary for letters such as the W and M, which are larger, and for I, J, and T, which are smaller.

Procedure for Making the Die.

1. Lay out and saw out material with the circle saw, using a carbon grit blade.
2. Draw the letter on one piece of material.



Drawing of a mold to make a 12" letter.

Boys' Club sign made in the Knoxville Occupational School plastic shop.

3. Drill a hole for the jig saw blade.

4. Saw the letter out with the jig saw, taking care to saw to the line throughout.

5. File the edges of the letter smooth with a cabinet file. Be careful not to have sharp edges or sharp corners. The surfaces must be smooth to avoid tearing the plastic.

6. Grooves ½ inch from the letter and ¼ inch in depth are cut in the outer rim. The carbon grit saw blade is used because Formica will dull the wood cutting blade.

7. Measure and bend the band iron to be fitted into the grooves. Then file sharp edges smooth. This rim of band iron helps seal the die air tight in the forming press.

8. Fasten the letter cut-out section onto the other piece of Formica and plywood.

Now the die is ready to form a letter.

Procedure for Making the Letter

1. Saw out ⅛ inch plastic.

2. Heat in the oven at a temperature of 350° F. for 20 minutes. While the plastic is being heated, turn the forming press motor on and build up 60 to 100 pounds pressure.

3. Place the hot plastic on the rubber part of the forming press. In the center is an outlet for the air when the valve is open.

4. Place the die on top of the plastic and clamp down air tight by using the wheel on top of the forming press. Place the plastic and die in such a way that when the air is turned on, it will not be directed to any part of the letter. The part of the plastic first contacted by the air is cooled to the degree that it will not stretch evenly. In other words, place the plastic and die in the machine so that the air outlet will be directly under waste plastic.

5. Open the valve so the air will blow the plastic into the die and form the letter. Allow to stay in the forming press for 5 minutes till the plastic cools. Otherwise, the letter will be uneven.

6. Turn the air valve off and take the die and plastic out of the forming press. Remove the plastic from the die.

7. Saw the outer parts of the letter off by using the band saw; saw the inner parts off by using the jig saw. The inner parts may be cut out by using the carving

drill. The waste parts are saved to use in making the brackets.

8. Smooth outer edges of the letter on a disc sander and use a cabinet file to smooth other parts.

A welding torch is often used to polish the edges of the letters. If so, there is no need to sand or file the edges after sawing. Either the oxyacetylene or the electric welding method is satisfactory. Be sure to move the torch as it smooths the plastic. If it is kept in one place too long it will disfigure the letter or even set it on fire. The heat removes saw marks and brings the plastic back to its original color. A saw leaves a whitish effect. It is used extensively in working large pieces of plastic and where a highly polished surface is not needed.

9. To make the brackets for the letter, the scrap plastic is first heated and cooled to a level surface.

10. Then saw out strips 1¼ inches wide and glue up to cut out brackets ¾ x 1¼ x 1½ inches.

11. Make a thick solvent by dissolving plastic dust in ethylene dichloride.

12. To glue brackets in the letter, place one teaspoonful of solvent where the bracket is to be placed and set the bracket into the solvent firmly. The letter itself will determine where the brackets are to be placed and how many will be needed. For example, only three brackets are needed for a "V" and five are needed for a "W".

13. Allow the brackets to dry for 24 hours.

14. Use a belt or disc sander to sand brackets to a level surface. This is needed to insure maximum gluing strength.

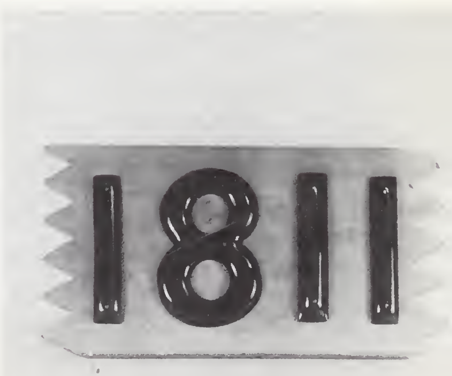
15. Before gluing the letters on, draw the wall lines and work out the space for each letter. All-purpose glue is used. Epoxy-cement is very good for this purpose.

16. Spread the glue on the brackets and place on the wall. Use masking tape to hold the letter in place while the glue is setting for 24 hours.

Business establishments with low buildings may want their signs mounted on the roof. Then the brackets are placed in the base of the letters and mounted on angle aluminum, using sheet metal screws.

Some inside letters may be made with a pantograph machine. The capacity of the machine is for letters ⅛ to 6 inches in size. Any style of letter may be engraved on plastic, for desk plates, door

House number made of wood and plastic.



Pantograph machine used for making signs, plaques, and templates.

plates, or wall plates. Several accessories are needed to make a variety of signs, for example, templates of letters (which are sold as copies), copy holders, clamps, reverse templates, templates reading right, and templates for different size letters.

The templates may be purchased or made. One large set of templates for reverse letters and letters reading right may be purchased; these guide the pantograph machine fonts, or sets, to create templates of smaller sizes.

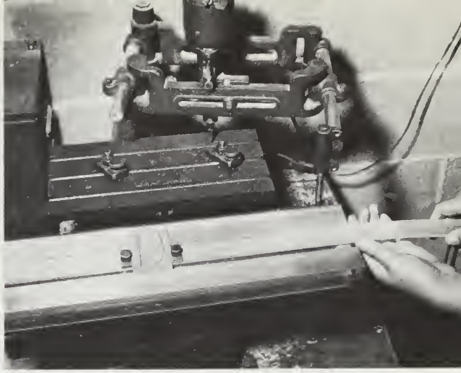
This is done by cutting strips of plastic on the circular saw, using a carbon blade, the same width as the template holders and at a 30° angle.

It is important that the plastic fit the copy holder so it will not move up and down when used. The strip of plastic is then clamped onto the pantograph machine table. The template to be traced is placed in the template holder. The machine is then set to cut the desired letter size. This is done by the reduction range on the pantograph bars. The table is moved backward and forward to cut the letters the correct distance from the top and bottom of the plastic. It is moved up or down to get the cutter within ⅛ inch of the plastic. Depth of engraving is set accurately with the micrometer dial, which is attached on the center bar and motor.

The setting is now ready for work. Place the tracing stylus at the outer edge of the template and turn on the motor. Lower the drop lever and trace the sides of the template. Raise the drop lever and place the tracing stylus in the letter part of the template. Lower the drop lever and trace the letter. The first template is now cut. If more than one of each is wanted, move the template out from the copy holder enough to allow room for sawing and sanding. The remainder of the font, or set, is cut in the same manner. It is important that all the templates be made before the machine is changed, to assure uniformity. As a new strip of plastic is needed, or as the strip is moved, it is important that it be placed accurately on the table.

Separate the templates on the strips of plastic, being careful to saw between the lines in the waste space alloted for sawing and sanding. This may be done on a fine-tooth band saw or with a circle saw using a carbon blade. The sides of each template are then sanded accurately on a disc sander. The templates are now ready to use.

To make a nameplate, the size of the letters is determined, usually ¾ to 1 inch in height. The width of the plastic should be 1½ inches; the length is determined by the length of the name. It is advisable to cut strips 1½ inches wide and use just the amount needed. If the nameplate is made of clear plastic, reverse templates are to be used. The letters are placed in the rack reading from right to left. If the nameplate is to be made on colored plastic, templates are placed in the copy holder reading left to right.



Testing a strip of plastic for size before engraving templates.

Procedure for Making a Nameplate on Black Plastic

1. Lay out and saw the plastic.
2. Set the pantograph machine for correct size.
3. Place the templates in the copy holder.
4. Clamp the plastic on the pantograph machine table so that the first letter of the name will be 3½ inches from the end.
5. Adjust the table for the correct height and center the letters in the plastic.
6. Set the correct depth for cutting.
7. Engrave the name and take the plastic off the machine.
8. Measure 3½ inches from the last letter cut and saw off.
9. Mark a line 1½ inches from each end.
10. Heat the plastic on a strip

Engraving templates on plastic strip.

heater on the line marked and bend to 90° angle.

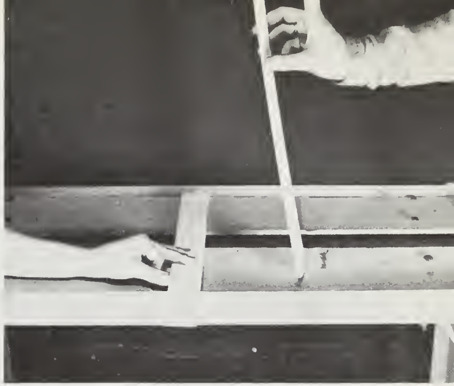
11. Sand on belt sander to desired angle.
12. Sand edges by hand.
13. Buff all edges to a high polish.
14. Apply gold paint or white lacquer.
15. Use paint or lacquer thinner to clean off excess paint.
16. Allow to dry, and polish with a clean polishing wheel.

The pantograph machine is also used for cutting emblems, figurines, and others. To carve a three-dimensional object, an automatic depth-of-cut regulator attachment is necessary. This assures a uniform depth of cut.

The method is similar to making a name plate. For example, if a Boys' Club emblem is to be engraved, a master copy of the emblem is clamped to the copy holder table and the plastic is clamped to the table under the cutter. The correct adjustments are made and the master emblem is traced with the tracing stylus. Be sure to raise the drop lever before moving the tracing stylus from one section to another.

Master copy of an emblem is drawn double size on soft material. After the drawing is made, trace over each line with a stylus, pressing hard enough to groove. The drawing is made larger to enable the craftsman to draw more

Pantograph machine carving a duplicate plaque.



Bending the ends of a name plate, using a strip heater.

accurately, and also some pantographs' maximum cuts are smaller than the template being traced. See that all grooves are smooth. If there are rough places or grooves outside the true lines, they will appear each time the template is used.

A permanent template is made by placing the drawing on the table of the pantograph machine and clamping a piece of plastic on the table under the cutter. The machine is set to cut the desired size and depth. Be sure that all adjustments are made before turning on the motor. The drawing and the plastic are clamped firmly; the table lock is tight; the depth gauge must be correct. The setting must be on the same number; for example, if the motor and the left bar are set on 1.6 and the right bar is set on a different number, the cutting will be at an angle.

After a careful check is made to see that the adjustments are ready, the permanent template is made by tracing the drawing and cutting it on the plastic.

Permanent templates are often

Plaque, made with the pantograph machine.

Emblems engraved on plastic for plaques, paperweights, and penholders.

WARNER ELECTRIC

Raised letters glued on plastic for changeable signs.

used for plaques in recognition of service, for engraving the emblem to be used as paperweights, on a pen set, on key chain fobs and on emblems for car nameplates.

The other type of sign to be discussed is the sign with raised plastic letters, molded from liquid plastic. This sign is used mainly as an inside sign. The letters are available in various sizes and colors.

Procedure for Making a Desk Sign Using Molded Letters

1. Select color of plastic and color of letters; for example, white letters on black plastic.
2. Determine the size of letters.
3. Figure the space necessary for letters; add 6 inches to the length and 1¼ inches to the width.
4. Saw out the plastic to the desired size.
5. Mark 1½ inches from either end.
6. Heat on a strip heater on the marked line and bend to a 90 degree angle.
7. Sand to the desired angle on a belt sander.
8. Hand sand the edges and buff to a high polish.
9. Lay out for the letters and glue them onto the plastic.

CAST LETTERS

Casting plastic numbers and letters.

Procedure for Casting Numbers and Letters

Molds for casting numbers and letters are available from many dealers of plastic supplies. They are plastic, somewhat flexible, and come in different sizes, such as ½, 1, and 1½ inches.

Dyes are used to make the letters and numbers, and pigments are used to get an opaque plastic. The amount of dye or pigment used determines the hue of the color.

1. Select the mold size wanted and apply mold release if needed.
2. Clamp the mold to a piece of plywood or masonite since it will not sit level on the worktable otherwise. (If the mold is not level, the letters cast will not be of uniform thickness.)
3. Determine whether opaque or transparent letters are to be used.
4. Select the color wanted.
5. Determine the amount of resin needed according to the number and size of the letters.
6. Pour the needed amount of resin in a squeeze bottle. Add the pigment or dye and mix thoroughly.
7. Add 10 drops of catalyst for each ounce of resin and mix thoroughly.
8. Fill the letter or number molds with the resin, but be care-

ful not to overfill them. To assure uniform letter size, fill all the letters to the same level.

9. Allow the letters or numbers to set in the mold for 3 or 4 hours.

10. Remove the clamps from the plywood and mold.

11. Remove the letters from the mold by pressing and bending the mold from the underside.

House number and sign made by casting liquid plastic.

Procedure for Mounting the Numbers to Make a House Number Sign

1. Determine what size plastic is needed. To do this, place the numbers on the plastic temporarily in order to measure the space. (Acrylite and Plexiglas are good materials for mounting the numbers.)
2. Measure and saw out the sheet plastic.
3. Machine sand the edges.
4. Hand sand and buff the edges.
5. Space the numbers by placing them on the sheet plastic.
6. Cement the numbers on with epoxy resin. If epoxy resin is not available, mix casting resin and catalyst for use as a cement. Allow the cement to dry for 3 to 4 hours.
7. Drill the holes and mount.

Questions on Making Signs

1. Name three types of plastic signs.
2. Why is a carbon grit saw blade used to make a die for a plastic letter?
3. Why should the die be placed in the forming press so the air outlet will be directly under a waste part of the plastic?
4. How are the inner waste parts of a letter cut out?
5. What are the waste parts used for in making a 12 inch letter?
6. How may the edges of the 12 inch letter be polished?
7. How are the brackets glued in the letters?
8. How are the letters glued on a wall?
9. What types of signs are made with the pantograph machine?
10. How are templates made in the school shop?
11. What kind of a unit is to be used to heat plastic when making a name plate?
12. How is a master copy of an emblem made?
13. How is a sign made using raised letters?
14. How may raised letters be made in the school shop?

22 PROBLEM SOLVING

Special problems and procedures are covered in this chapter. Included are:

- Working with plastics alone.
- Combining plastic with wood.
- Combining plastic with mechanical drawing.
- Combining plastic with metal.
- Combining plastic with electricity.
- Combining plastic with auto mechanics.
- Using scrap material.
- Injection molding.

• ***Suggested projects for the plastic unit.***

- Ferris-wheel Lazy Susan.
- Three-tray Lazy Susan.
- Curved-hole paperweight.
- Curved-shape paperweight.
- Engraved and formed signs—*no procedures or illustrations.*
- Desk set—*no procedures or illustrations.*

After making these projects you will have learned to use the major equipment needed, as well as securing valuable knowledge of the properties of plastic. The projects are suggested because they offer problem solving experiences and should encourage further study of the possibilities of plastic in science and industry. The projects that are illustrated and not discussed can be used in more extensive problem solving.

• ***Suggested projects for combining wood and plastic.***

- Lazy Susan made of wood, plastic, and metal.
- Planter with flower container made of plastic.
- Dies and molds for forming plastic.

Projects for combining plastic with mechanical drawing.

- Tear-drop penstand.
- Drawing board.
- T-square and triangles.
- Template emblems.
- Telephone swivel—*no procedures.*

• ***Projects for combining plastic with metal.***

- Knife handles, hammer handles, and screwdriver handles.
- Plastic tray for sheet metal tool box.
- Plastic forming press.
- Dies and molds for forming plastic.
- Cuff links.

• ***Projects for combining plastic with electricity.***

- Throat light.
- Lamps.

• Making a strip heater used for bending plastic—*no procedures or illustrations.*

• ***Projects for combining auto mechanics and plastic.***

• Plastic rack to hold airplane model engine while working on the engine.
• Hub cap—*no procedures or illustrations.*
• Tail-light covers.
• Plastic covers to enable observation of engine working parts.

• ***Projects for using scrap material.***

• Mixing bowls.
• Plates.
• Notepaper holder.

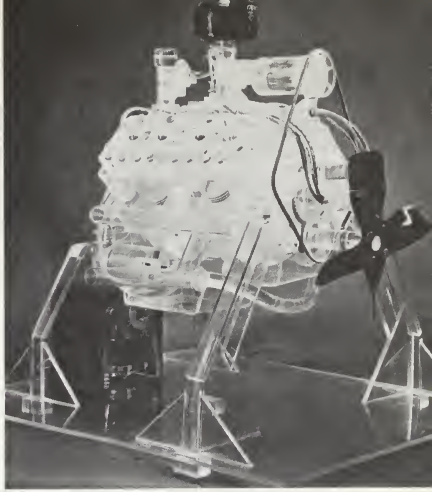
• ***Project for injection molding.***

• Molds to use for injection molding.

Plastic as a unit in general shop makes possible a wider knowledge of common materials as well as added skills. To add plastic to the general shop curriculum, the following equipment is recommended:

1. One or more buffers.
2. A plastic forming press.
3. A pantograph machine.
4. A portable drill for carving.
5. An electric oven.
6. A laminating press.
7. A strip heater.

Each piece of equipment is discussed elsewhere in this book. The pantograph machine, the forming press, and the strip heater may be made in the general shop.



Old-style Mercury engine duplicated in plastic by Robert Reguerth, Cleveland, Industrial Arts Award winner.

PROJECTS FOR THE PLASTIC UNIT

Ferris-wheel Lazy Susan Procedure

A. Base

1. Lay out a base 8 inches in diameter by 1 inch, using clear plastic.
2. Saw out with band saw.
3. Glue wood disc on masking paper for use in assembling the faceplate. Epoxy-cement is good for this. Clamp with a spring clamp and allow the glue to set for 24 hours.
4. Assemble on the lathe and turn to the desired shape.
5. Sand the plastic smooth while it is on the lathe.
6. Break the paper glue joint to disassemble from the faceplate.
7. Buff the plastic to a high polish.

Ferris wheel Lazy Susan.

B. Swivel

1. Lay out a circle 4 inches in diameter using 2 inch stock.
2. Follow the same procedure as for the base to glue and assemble on the lathe.
3. Make a ring by cutting straight through the plastic, using the parting tool.
4. Take the center portion out and sand the inside and outside of the ring while it is on the lathe.
5. Break the paper glue joint to disassemble from the lathe.
6. Buff the ring to a high polish.
7. Turn out on the lathe a 3 inch circle, 2 inches in thickness, following the same gluing procedure as with the ring; assemble on the lathe for sanding and buffing.

C. Wheels

1. Make a pattern for the wheels as shown in the drawing.
2. Select the desired color and lay out the wheels 12 inches in diameter and 3/16 inch thick.
3. Drill the hole for the jig saw blade.
4. Assemble on the jig saw and cut out inside portions.
5. Cut the outside of the wheels on the band saw.
6. File, hand sand, and buff the edges.

D. Axle

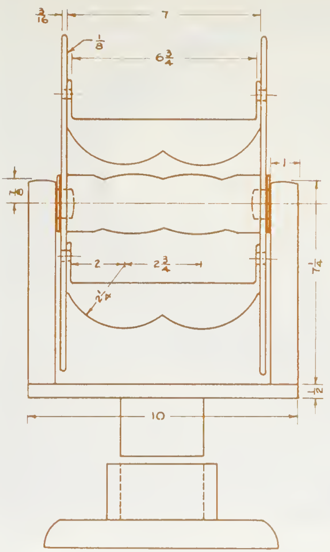
1. Lay out material for the axle 2 x 2 x 8 inches.
2. Assemble on the wood lathe and turn out the axle to the desired shape. (A ball bearing center for the tail stock is needed in turning plastic to prevent heating.)
3. Sand the plastic while it is on the lathe.
4. Remove from the lathe and drill holes 1 inch in diameter and ½ inch deep in both ends.
5. Buff the axle to a high polish.

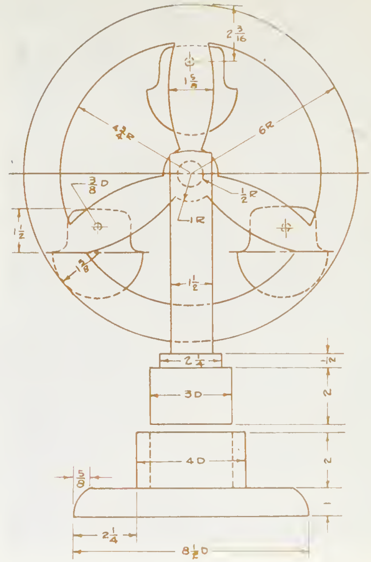
E. Uprights and Crossbar

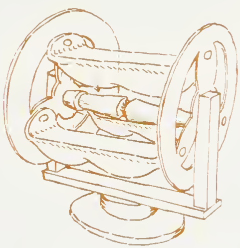
1. Lay out dimensions shown in drawing.
2. Saw out with the circle saw using a carbon grit blade.
3. Sand the sawed surfaces by hand, using fine sandpaper.
4. Buff to a high polish.

F. Containers

1. The die is made with the inside dimensions 4 x 4½ x 7 inches.
2. Select color; lay out and saw plastic from 3/16 inch stock.







3. Heat the plastic in the oven 325 degrees F. for 20 minutes.

4. Place the hot plastic on the center of the rubber portion of the forming press and place the die on top.

5. Clamp the die down air tight by turning the wheel.

6. Turn the air on.

7. Allow the plastic and die to stay in the forming press until the plastic cools.

8. Take the plastic out of the forming press and trim the waste parts off with the band saw.

9. Sand the saw chips out on the disc and belt sanders.

10. Hand sand and buff the edge to a high polish.

11. Drill the holes in the ends for ⅜ inch plastic dowels.

12. Heat the ends on the strip heater and bend to a 90 degree angle.

G. Assemble

1. Glue the ring of the swivel to the base.

2. Glue the center part of the swivel to the crossbar.

Three-tray Lazy Susan made of clear and light blue plastic.

3. Glue 1 inch dowels to the uprights.
4. Glue the uprights to the crossbar.
5. Glue the ⅜ inch dowels to the wheels to swing the containers.
6. Glue the wheels to the axle.
7. Place the wheels and the axle in the dowels.
8. Put the Lazy Susan containers in place. Now it is ready to turn around or over, as needed, to serve the desired "goodies."

Three-tray Lazy Susan Procedure

A. Base and Swivel

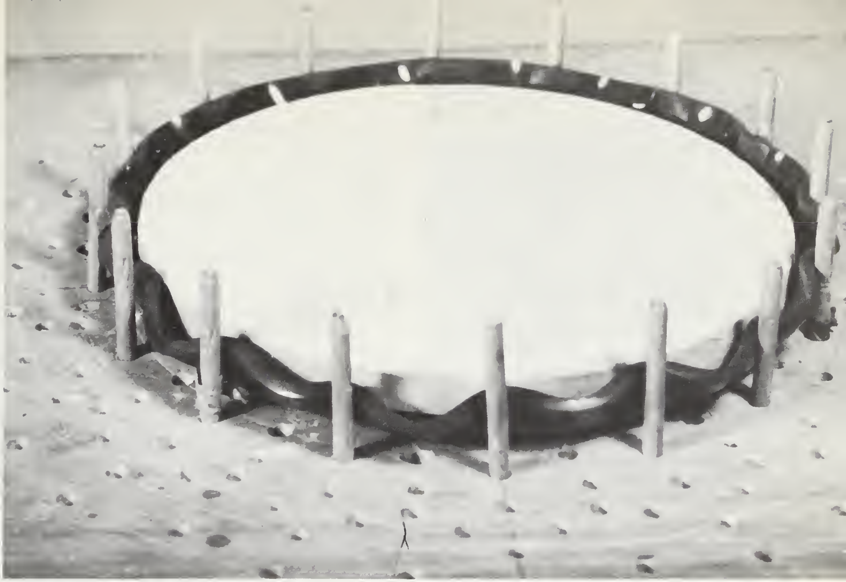
1. The base and swivel for the three-tray Lazy Susan is made in the same manner as for the ferris-wheel Lazy Susan.

B. Uprights

1. Lay out and saw clear plastic 2 x 2 x 9 inches.
2. Draw lines from corner to corner of both ends to find the centers.
3. Saw grooves in one end for the live center of the lathe and drill a hole with a ⅛ inch drill for the tail stock center.
4. Sand the corners off the plastic before assembling in the lathe.
5. Turn the plastic to desired shape and sand smooth.
6. Remove the plastic from the lathe and buff to a high polish.
7. Saw the waste ends off and saw the main part in two at the center.
8. Sand each end smooth and true on a disc sander.

C. Tray Mold

1. On a smooth piece of wood, lay out a 10 inch circle, a 12 inch circle, and a 14 inch circle, using the same center.
2. Mark off and drill sixteen holes ¼ inch in diameter evenly spaced in each circle.
3. Assemble ¼ x 2½ inch dowels in each hole; their tops should be rounded and smooth.
4. Mark off and saw out a 9½, an 11½, and a 13½ inch wood disc, using ½ inch stock.
5. Sand the edges smooth.



Mold and tray for the three-tray Lazy Susan.

D. Trays

1. Lay out and cut a 12 inch, a 14 inch, and a 16 inch circle of plastic using $\frac{3}{16}$ inch material.

2. Sand and buff the edges of each disc until they are smooth and highly polished.

3. Heat the 12 inch circle in the oven at a temperature of 325 degrees F. for 20 minutes.

4. Place the hot plastic in the mold and form evenly.

5. Heat the 14 and 16 inch discs and form in the same manner.

E. Assemble

1. Glue the ring of the swivel to the base, being careful to place it in the center of the base.

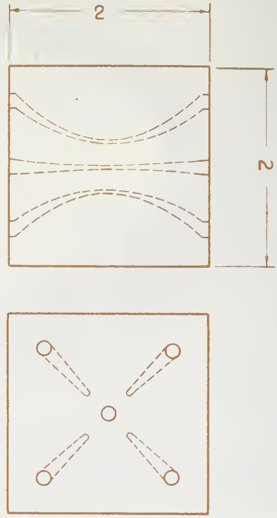
2. Glue the center portion of the swivel to the bottom of the 16 inch tray. Be sure to get this part in the center. Gluing off-center will cause the tray to turn unevenly.

3. Glue one upright to the bottom of the 14 inch tray and the other upright to the bottom of the 12 inch tray; must be in exact center.

4. Glue the other ends of the uprights on top of the 16 and 14 inch trays in the center.

5. Place the center section of the swivel in the swivel ring. The

Curved-hole paperweight.



Lazy Susan will turn evenly if all glue joints are made correctly.

Curved-hole Paperweight Procedure

1. Lay out and saw a 2½″ cube of clear plastic.
2. Machine sand, hand sand, and buff all surfaces to a high polish.
3. Heat the plastic in the oven for 45 minutes at a temperature of 325 degrees F.
4. Place between two pieces of Formica and plywood; then place in a vise and turn until the heated plastic is one-third its original thickness.
5. Cool for 15 to 20 minutes.
6. Take the plastic out of the vise and drill holes in each corner with a ⅛ inch drill.
7. Place the plastic back in the the oven and heat until it resumes its original shape, for 30 to 35 minutes.
8. Take the plastic out of the oven and allow it to cool; then polish the item.

Curved-shape Paperweight Procedure

1. Lay out and saw a 2½ inch cube of clear plastic.
2. Machine sand, hand sand, and buff all surfaces.
3. Heat the plastic in the oven for 45 minutes at a temperature of 325 degrees F.
4. Place the hot plastic in a vise between Formica and plywood blocks.
5. Tighten the vise until the plastic is one-third its original thickness. Leave in until it is cool, from 30 to 35 minutes.
6. Heat the plastic in the oven at a temperature of 325 degrees F. for 8 to 10 minutes.

7. Take the plastic out of the oven and allow it to cool. The plastic is now in a curved shape with the center its thinnest part. This is because it was taken out of the oven before the center portion was heated enough to go back to its original shape. The project may now be considered finished, or a design may be carved in.

Curved-shape paperweight.

PROJECTS COMBINING WOOD AND PLASTIC

Procedure for Plastic Planter or Container

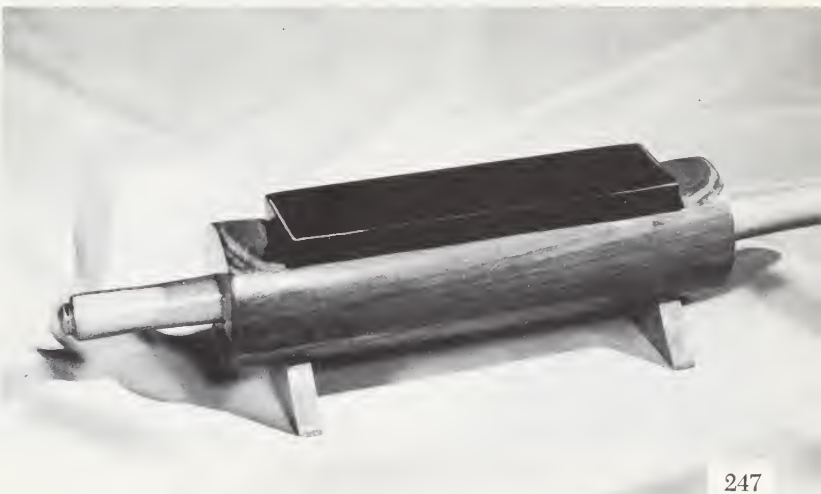
The *die to form the plastic container* is made as follows:

1. Lay out and cut the ends and sides of the die to assure desired inside dimensions.

2. Lay out and saw Masonite to cover the top of the die.

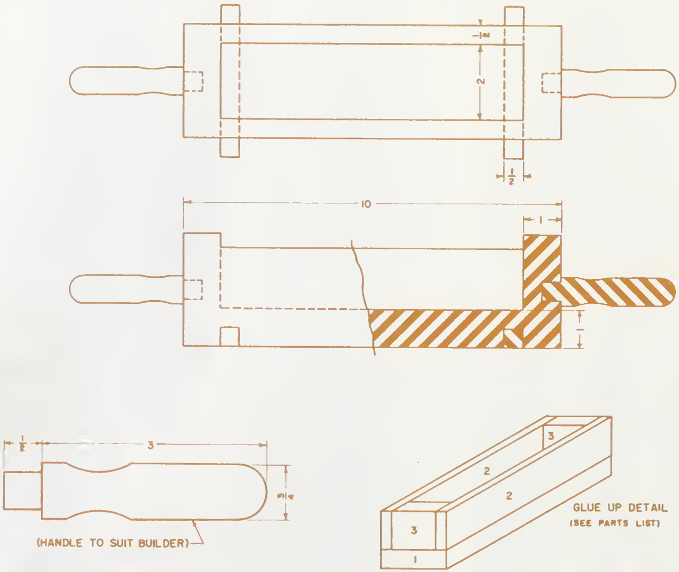
3. Saw the grooves in the bottom edges, the sides, and the ends. These are for the band iron.

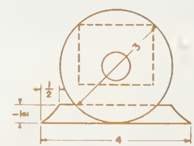
Planter made of wood and plastic.



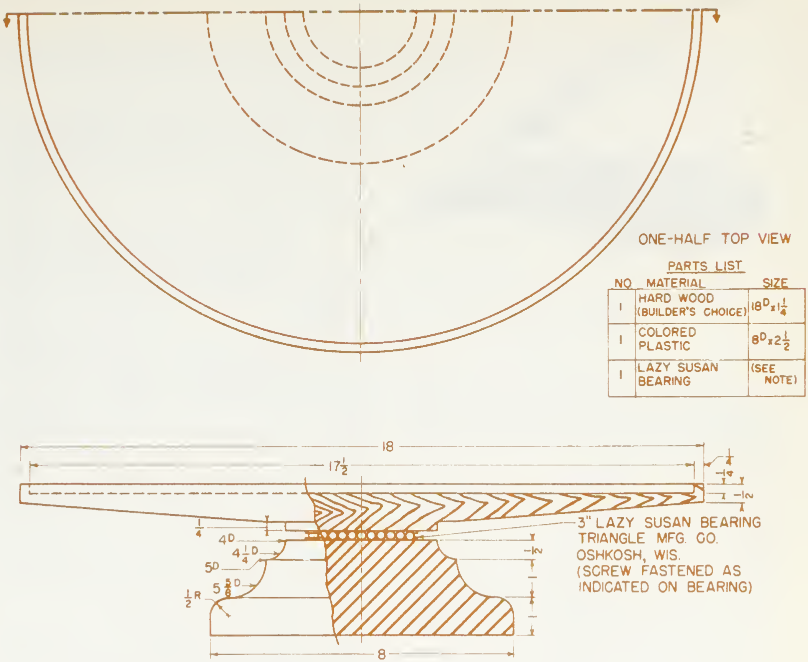
PARTS LIST

NO.	MATERIAL	REQ'D	SIZE
1.	COLORED PLASTIC	1	1x3x10
2.	COLORED PLASTIC	2	[illegible]x2x10
3.	COLORED PLASTIC	2	1x2x2
4.	COLORED PLASTIC	2	[illegible]x3[illegible]
5.	COLORED PLASTIC	2	[illegible]x[illegible]x4





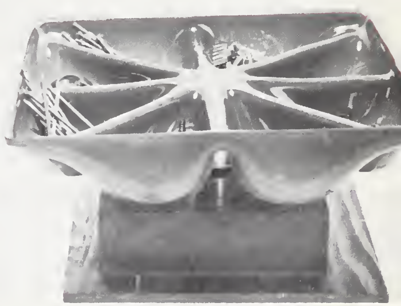
Rolling pin planter—made of wood and plastic.



PARTS LIST

NO.	MATERIAL	SIZE
1	HARD WOOD (BUILDER'S CHOICE)	18D x 1¼
1	COLORED PLASTIC	8D x 2½
1	LAZY SUSAN BEARING	(SEE NOTE)

Lazy Susans made of wood, metal, and plastic. The drawings give dimensions needed to make the Lazy Susan on the left.



Monogrammed tear-drop pen stand.

4. Assemble the parts by nailing the ends to the sides and the Masonite on top.

5. Bend the band iron and fit it in the grooves. This assures no air leakage when the die is in use.

To use the die to form the flower container, plastic $\frac{1}{8}$ inch in thickness is selected. The plastic is cut sufficient in size to cover the bottom of the die. It is then heated in the oven at a temperature of 325 degrees F. for 20 minutes and placed in the forming press with the die on top and clamped down air tight. The plastic is allowed to stay in the forming press for 5 minutes to cool. It is then taken out and the waste portions cut off with a band saw. The edges are sanded and buffed to a high polish.

PROJECTS IN MECHANICAL DRAWING AND PLASTIC

Procedure to Draw and Make the Tear-drop Pen Stand

1. Establish point O at any given place.

2. With O as center, draw lines O A and A B, meeting at 90 degrees at A.

3. With A as center, draw to a radius of $1\frac{11}{16}$ inches, striking an arc to determine A on the extension of A B.

4. With O as center, draw line O C through point B, point C being established $1\frac{5}{8}$ inch radius from B.

5. With C as center and the radius $1\frac{5}{8}$ inches, strike arc B D of indeterminate length.

6. With B as center and the radius $2\frac{1}{2}$ inches, strike an arc to intersect the indeterminate arc above at D, thus establishing the point of tangency.

7. Draw line D E from D through point C, the point being $1\frac{5}{8}$ inches from D.

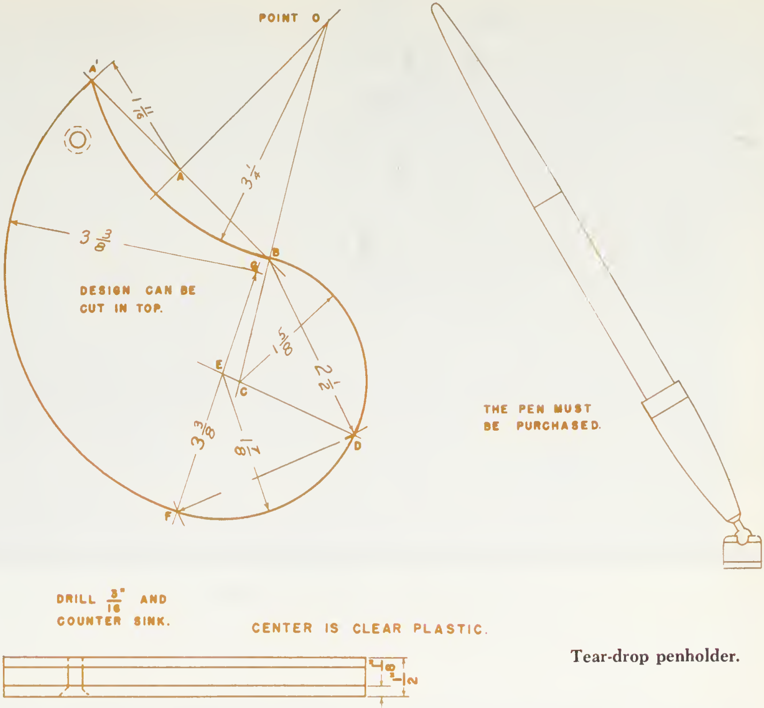
8. With E as center and the radius of E D, strike an arc from D of indeterminate length.

9. With D as center and the radius $2\frac{1}{2}$ inches, strike an arc to intersect above, thus establishing point F.

10. From F, draw a line of indeterminate length passing through point E. On this line with F as center and the radius $3\frac{3}{8}$ inches, strike a intersecting arc, thus establishing point G.

11. With G as center and the radius $3\frac{3}{8}$ inches, strike arc F A, thus completing a series of tangent arcs forming the outline of the base.

12. Cut out the pattern and transfer it to the plastic. Cut out two black pieces and one clear piece.



Tear-drop penholder.

13. Glue the clear piece between the black pieces by soaking the clear piece in glue and clamping, using two pieces of Formica and plywood as protection. Do not get glue on the outer parts of the black plastic.

14. Sand the edges smooth on the belt and disc sanders and buff them to a high polish.

15. Engrave the letters with the pantograph machine.

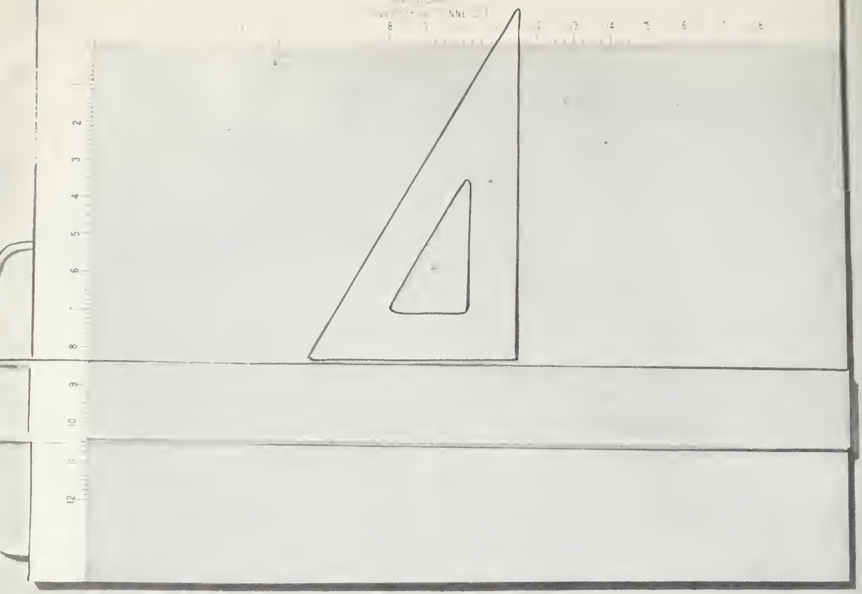
16. Apply gold paint in the letters and allow to dry. Clean the excess paint off, using lacquer thinner and a paper towel.

17. Drill the hole for the penholder and countersink the hole.

18. Assemble the penholder on the pen stand base.

• ***Plastic drawing board, T-square and triangles.***

To make a plastic drawing board with the inch and inch fraction marks engraved on the top edge and left side, the pantograph machine is set to cut the lines exactly. The l's and the I's are used as templates. Two strips of white plastic ⅛ x 2 x 18 inches are cut for the dimension marks. These



Drawing board, T-square, and triangle.

strips are clamped on the pantograph machine after it has been set to cut the correct spacing. The l's and the I's are placed in the copy holder. A pencil mark is made on the templates for the height of each mark.

Before starting the engraving, be sure all parts are clamped firmly and adjustments are correct. There are not sufficient templates of the I's and l's in a font of letters for all of the marks needed. Therefore the templates are moved as they are used. *Keep them in correct spacing.*

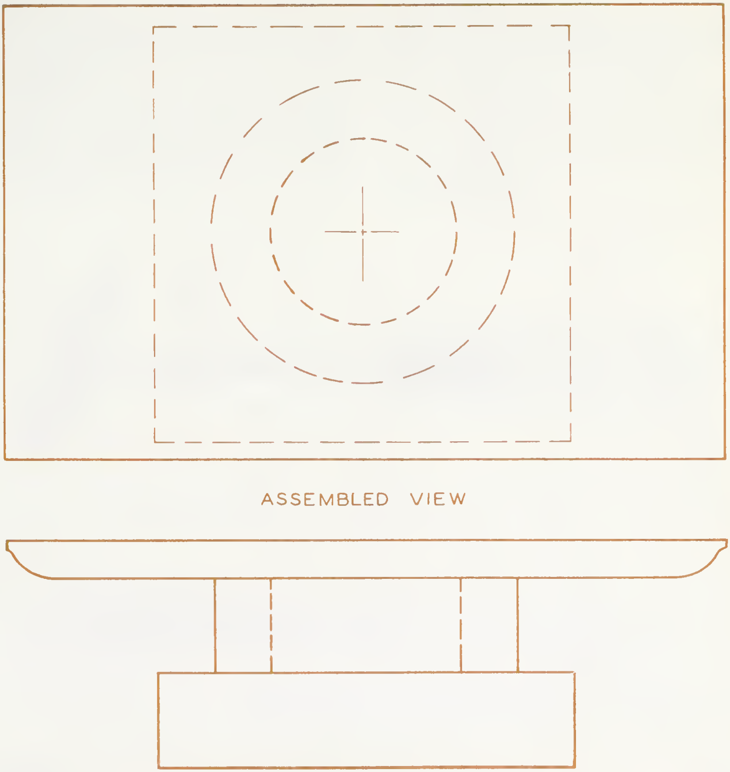
After the engraving has been completed, black lacquer is placed in the engraved parts. The excess lacquer is cleaned off with lacquer thinner after it is dry. A clear piece of plastic ⅛ x 18 inches is cut and the white strips are glued on the top and the left edges. Then a colored piece ⅛ x 16 x 16 inches is cut and glued on the other part of the clear plastic.

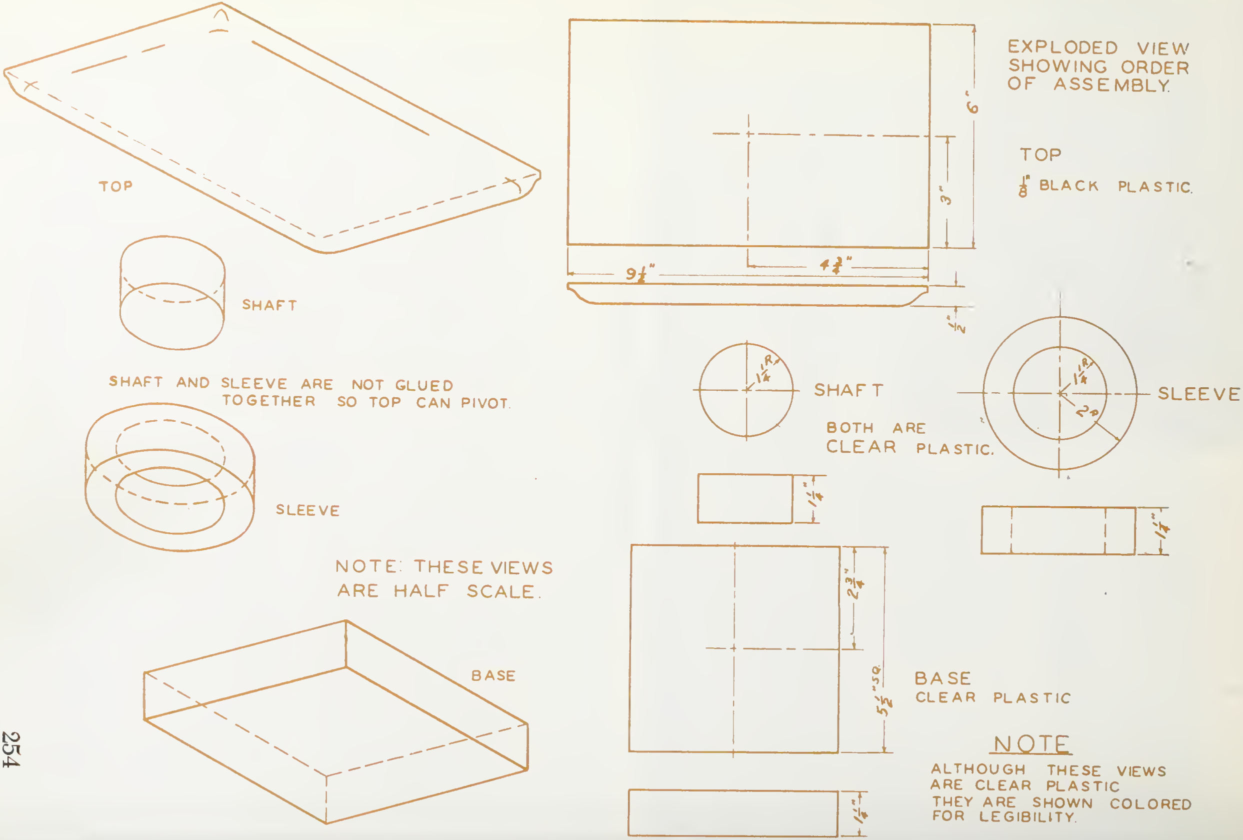
After the glue joint has set, the edges of the drawing board are sanded and buffed to a high polish. Be sure to sand the edges straight and to keep the corners at a right angle.

The *head* of the T-square is designed and cut from clear plastic 3/16 inch in thickness. The *blade*

Telephone swivel made of clear and black plastic.

Telephone stand—made to swivel as a Lazy Susan. (Drawing continued on next page.)




TOP
SHAFT
SHAFT AND SLEEVE ARE NOT GLUED TOGETHER SO TOP CAN PIVOT.
SLEEVE
NOTE: THESE VIEWS ARE HALF SCALE.
BASE
EXPLODED VIEW SHOWING ORDER OF ASSEMBLY.
6"
3"
9¼"
4⅝"
½"
TOP
⅛" BLACK PLASTIC.
R 1¼"
SHAFT
BOTH ARE CLEAR PLASTIC.
R 1¼"
2 D
SLEEVE
1¼"
1¼"
2¾"
5½" SQ.
BASE
CLEAR PLASTIC
1¼"
NOTE
ALTHOUGH THESE VIEWS ARE CLEAR PLASTIC THEY ARE SHOWN COLORED FOR LEGIBILITY.

of the T-square is cut from clear plastic ⅛ x 2 x 20 inches. The edges are sanded and buffed. Sand the blade of the T-square straight and true. The blade is glued on the head at a right angle. Use a framing square to assure a correct joint.

The *triangles* are drawn on ⅛ inch clear plastic and cut out with a carbon grit saw blade to eliminate saw chips. In sanding and buffing the outer edges, keep the angles straight and accurate. The center portion is cut out with the jig saw.

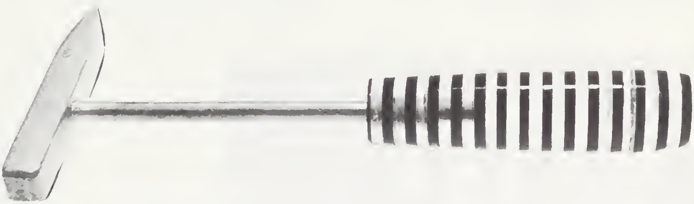
• ***Drawing emblem to be used in plastic.***

The need for an accurate drawing is important in that it duplicates an emblem that may be used by many.

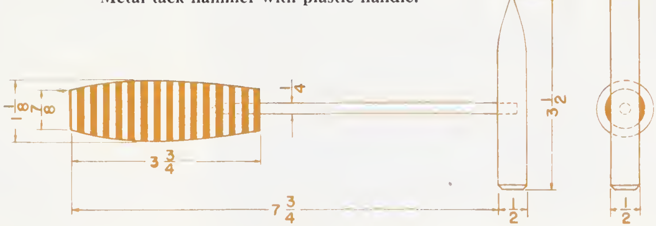
PROJECTS WITH METAL AND PLASTIC

Procedure to Make the Tack Hammer Handle

1. Select the desired colors of plastic and saw out 1½ inch squares.
2. Glue the squares by soaking them in glue and stacking them straight. They may be held by hand until the glue sets, or a jig may be made to hold them in place. The setting time is from 3 to 5 minutes.
3. After the glue joints have hardened for 24 hours, turn to the desired shape on the lathe.
4. Drill and tap the hole for the metal portion of the handle.
5. Cut the waste portions off and sand and buff the handle to a high polish.



Metal tack hammer with plastic handle.



Utensil handles made of Plexiglas.

ROHM AND HAAS

Procedure for Making the Tray Die.

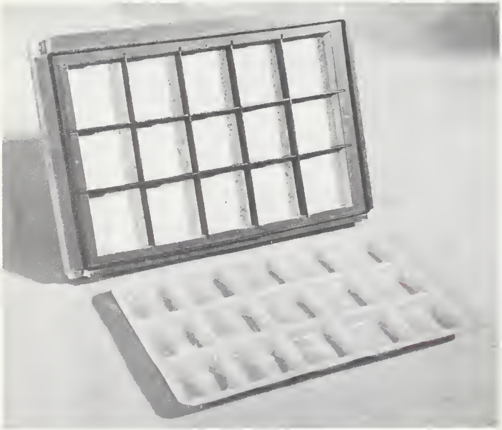
The size is determined by the size of the box and by individual needs.

1. Cut two pieces of Formica and plywood the desired size.

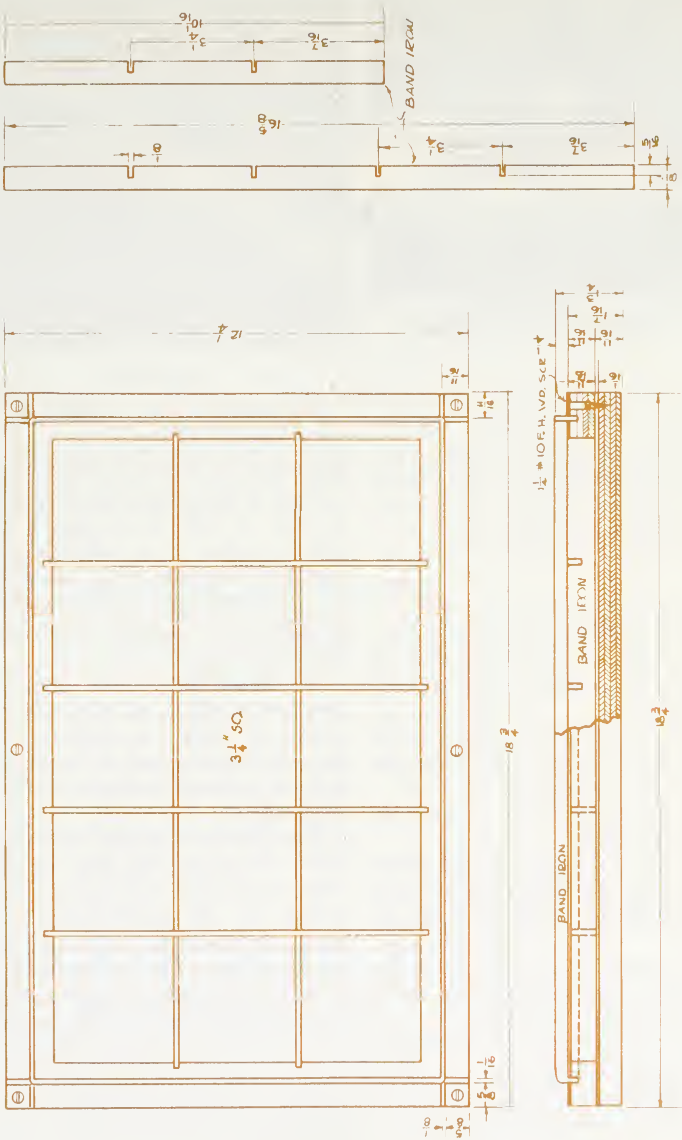
2. Mark off and cut out the center portion of one piece of the Formica and plywood.

3. Mark off and cut out slots for the band iron. These are spaced to meet the needs of the individual. All slots may be equally spaced or spaced for sections of different dimensions.

4. Cut a groove for ½ inch band iron to be assembled in the top section of the die. This is used to make the die air tight.

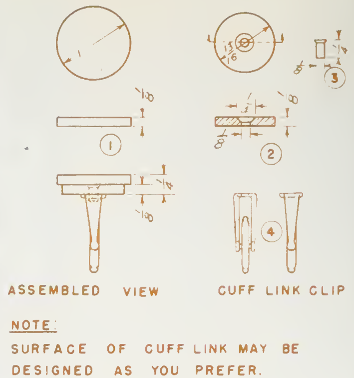


Tray for a sheet metal tool box and the die to form the tray.



Drawing of a mold to make a sectional plastic tray.

Monogrammed cuff links.



5. Fasten the two pieces of Formica and plywood together with nails or screws.

6. Assemble the band iron in the grooves and slots.

Procedure for Forming the Plastic Tray

1. Select color and cut out the desired plastic.

2. Heat in the oven for 20 minutes at a temperature of 325 degrees F.

3. Place the hot plastic in the forming press and place the die on top of the plastic.

4. Turn the wheel to form an air tight seal.

5. Turn the air on and allow the plastic to stay in the forming press until it is cool. Turn the air off.

6. Take the plastic out of the forming press and cut the waste parts off with the band saw.

7. Machine sand the saw marks out with the belt or disc sander.

8. Hand sand the edges and buff them to a high polish.

PLASTIC AND ELECTRICITY PROJECTS

Procedures for Making a Throat Light

One of the properties of plastic is that it will bend light rays, which makes it a valuable material to combine with the working of electricity. The throat light is illustrated and discussed here to show this use.

To make the throat light, a piece of plastic 1 x 1 x 8 inches is used. A hole is drilled and threaded in one end of the plastic to hold a pencil flashlight ¾ inches in diameter.

The plastic is sanded to the desired shape on the disc sander. Then hand sand and buff to a high polish on all parts except the ends. Using gloves, heat the blade of the throat light by holding it over the outer heating unit. Only the part that is to be bent is to be heated. Heat all portions uniformly, so that blisters will not appear. This is accomplished by turning the plastic, testing it by

Throat light.

TV light.

the hands, and removing it from the heat when it becomes sufficiently flexible to bend to the desired shape.

After the plastic is cooled, the flashlight is assembled in the end drilled and threaded for that purpose. The light rays travel through along all bends that have been formed.

This light has many uses to penetrate spaces where vision is blocked. A similar light is made for the mechanic by using a larger piece of plastic and a larger flashlight. The plastic is bent or twisted to any desired shape.

- ***T V light.***

Size of the bulb will determine size of the base to house the light fixture. Bulb is approximately 2 inches long.

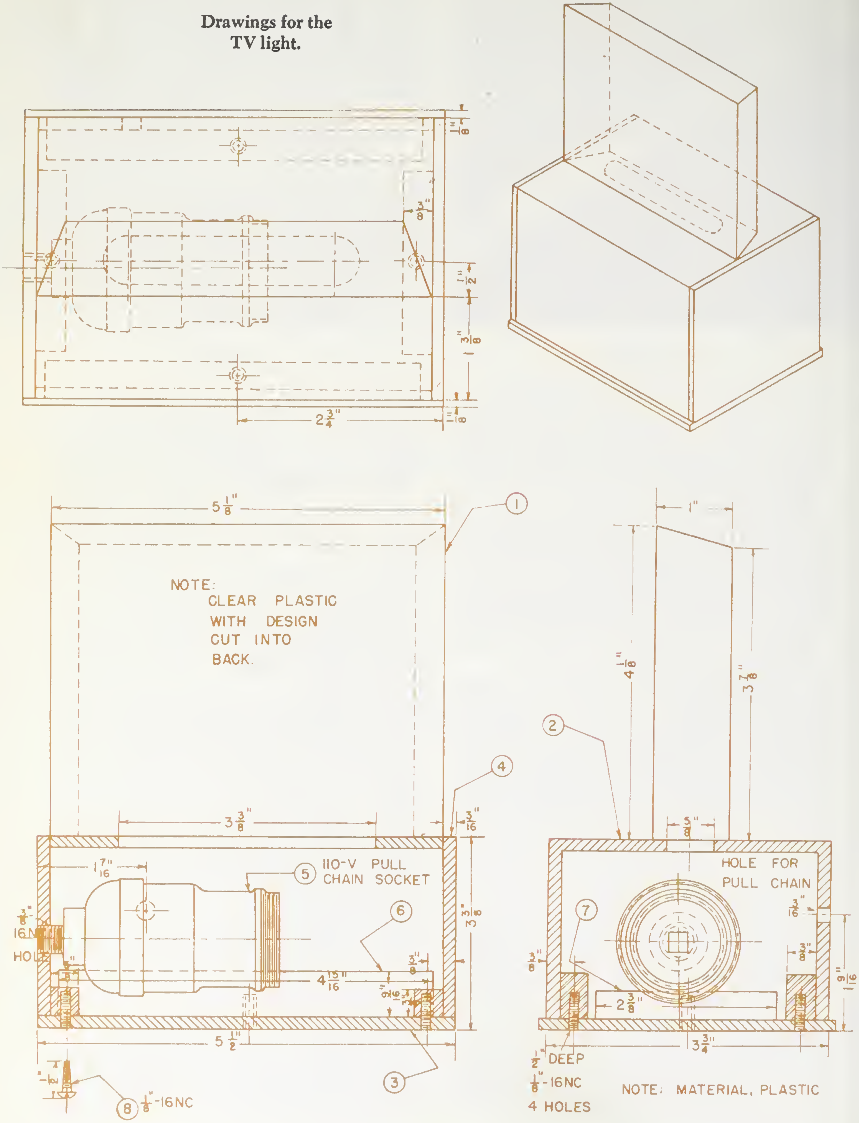
Procedure—Base

1. Determine the size of the base needed by assembling the light bulb in the socket. Allow at least 1 inch clearance between bulb and plastic to avoid heating.
2. Cut a piece of white plastic large enough for both sides and top.
3. Heat plastic on a strip heater and bend sides to 90°.
4. Cut the two ends and assemble light nipple in the center of one end.
5. Sand and buff the ends to a high polish.
6. Glue ends to the sides and top.
7. Drill ¼ inch holes in the top of the base, so spaced as to be covered by upright. The purpose of the holes is to permit light to go into upright.
8. Drill a hole in the back for the light cord.

Procedure—Carved Upright

1. Saw 1 inch piece of clear plastic to a length and height proportional to base.

Drawings for the TV light.



2. Saw a 45 degree beveled edge on ends.
3. Sand all edges on a machine sander.
4. Hand sand and buff all edges except bottom of upright.
5. Carve the flowers in the plastic and apply dye.
6. Fill the carved portion with plaster of paris.
7. Carve leaves and apply dye.
8. Fill the carved portion with plaster of paris.
9. Buff off excess plaster.
10. Glue the upright onto the base.
11. Assemble the light fixture.

Ceiling light fixture.

- ***Ceiling light fixture.***

Procedure—Molds

1. Cut a piece of plywood and Formica 14 inches x 14 inches.
2. Cut four strips of wood 1¾ inches x 2¼ inches x 14 inches.
3. Using a saw or a shaper, cut the desired design on the four strips of wood.
4. Using a miter saw, cut the corners at a 45 degree angle.
5. Smooth sand the wood strips.
6. Fasten the wood strips onto the Formica with glue and screws, making a frame.
7. Fasten a piece of band iron around the edge.

Procedure—Mold for Box Outlet Cover

1. Cut a hardwood disc 2 inch x 7 inch x 7 inch.
2. Fasten the faceplate onto the wood and assemble on the lathe.
3. Turn the edge of disc until smooth.
4. Cut a 6 inch diameter space 1 inch deep in the face of the wood.
5. Sand smooth and apply buffing compound while it is on the lathe.
6. Polish with cloth or paper towel.
7. Apply paraffin and polish again—still on the lathe.

Procedure for Making the Shade

1. Cut a piece of white plastic ⅛ inch x 14½ inches.
2. Heat in pre-heated oven at 300 degrees for 6 or 7 minutes.
3. Place the hot plastic and the mold in the forming press.
4. Apply air pressure and allow to cool 5 minutes.
5. Remove the plastic from the forming press and mold.
6. Cut waste portions from the edges with a band saw.

Molds for ceiling light.

7. Sand the edges smooth, and buff.

8. Mark the center of the plastic and drill a ⅝ inch hole there.

Procedure for Making the Outlet Box Cover

1. Cut a piece of white plastic ⅛ inch x 7 inches x 7 inches.

2. Heat in a pre-heated oven at 300 degrees for 6 or 7 minutes.

3. Place the hot plastic and the mold in a forming press and make it air tight.

4. Apply air pressure and allow to cool 5 minutes.

5. Remove the plastic portions from the forming press and mold.

6. Saw waste portions off with a band saw.

7. Sand the edges and buff to a high polish.

8. Mark and drill holes to fit into the outlet box.

9. Assemble the light fixture.

AUTO MECHANICS AND PLASTIC

Procedures in Making a Plastic Rack

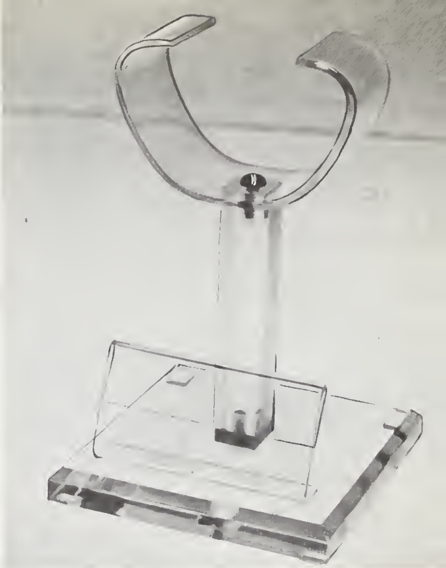
The rack made to hold the gas engine for a model airplane is made of all clear plastic. It holds the engine while it is being repaired, as well as for study.

The base and upright of the stand may be made as illustrated or changed to suit the individual. The top part of the rack is made by the use of a jig prepared to form the plastic. This jig is made by drawing the desired shape and size on wood and cutting it out with a jig saw. A cabinet file and

sandpaper are used to smooth the edges.

The plastic is cut, sanded, and buffed to a high polish before heating in the oven. Then it is placed in the jig and allowed to cool.

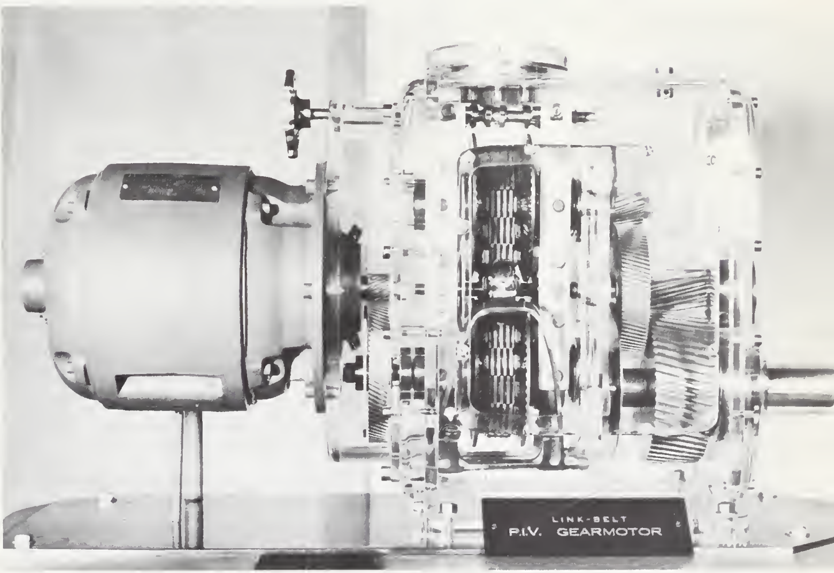
The rack is assembled with plastic, glue, and screws. Practice drilling and tapping the holes the correct size for the screws. If the

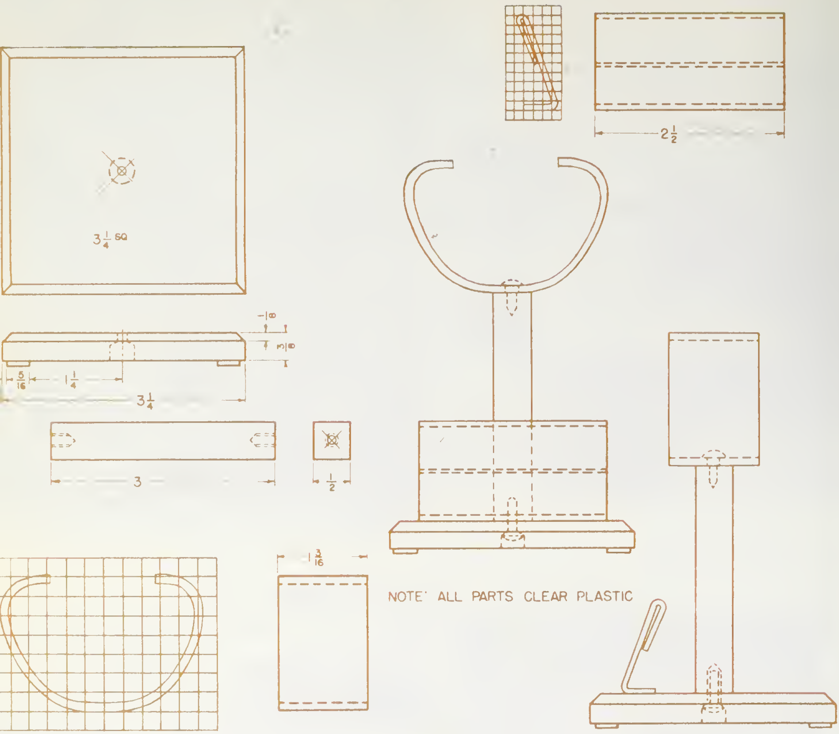


ROLEN HILL

Rack made of plastic to display a model airplane engine.

Housing for a gear motor made of Plexiglas.





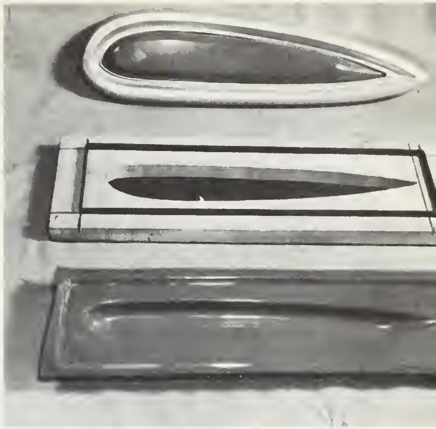
Drawing of rack made of plastic to display model airplane engine.

holes are too large the rack will be loose; if the holes are too small the screws will break the plastic.

Inspection plates made of plastic aid the auto-mechanics student to observe the actual working of parts. Plastic covers for mechanical assemblies are used to protect them from dust, as a safety precaution, for display purposes, and as a visual aid in teaching. Covers are made by use of a mold and forming press. To see each part in actual operation is valuable. Acquiring knowledge and skill in the working of plastic may help a person to acquire knowledge and skills in other phases of industrial arts. The metal covers are used as templates by tracing around them on clear plastic and cutting the shapes out. Special accuracy in marking and drilling is required for bolts used to fasten the plate to the working part of the automobile.

The making of machine safety guards of clear plastic is a valu-

Mold and plastic formed for tail light cover.



Tail light cover, mold, and formed plastic as it is taken from the mold.

able project in several ways. The guard will aid in safety, and permits you to see the working parts of the machine at the time it is in operation. Also, any part not functioning properly is easily observed.

• *Tail-light cover.*

Procedure for Making the Mold

1. Obtain the chrome portion of the tail-light for which the cover is to be made.
2. Make a pattern from the inside of the chrome portion.
3. Transfer the pattern onto wood.
4. Drill a ¼ inch hole in the waste portion that is to be cut out.
5. Assemble wood on a jig saw and cut the design.
6. File and sand inside edges until smooth.
7. With a circle saw, cut a groove around the cut-out portion.
8. Fasten band iron into the groove.
9. Fasten a piece of Masonite onto the back of the mold.

Procedure for Making the Tail-light Cover

1. Cut a piece of red plastic 1 inch larger than the band iron portion of the mold.
2. Heat in a preheated oven at 300 degrees for 10 minutes.
3. Place the hot plastic and mold into the forming press and make it air tight.
4. Turn on the air pressure and allow to cool 5 minutes.
5. Remove the plastic from the forming press and mold.
6. Cut off waste portions with a band saw and assemble in chrome portion of tail-light cover.

USING SCRAP MATERIAL

Industry, as a rule, is concerned about developing useful products from their waste materials. Once a use has been found and the product produced, it is known as a by-product. For example, the paraffin that is used on the cutting wheel when buffing plastic is a by-product of the petroleum industry. Concern for developing useful products from scrap material is shared by individuals as well as industry. What to do with the tons of waste we produce every day is a problem that becomes increasingly more difficult to solve. Awareness, followed by individual effort, is at least one step toward the solution. If each person can discover his own methods of cutting down waste, all will eventually benefit. The following projects will show you a few ways to help cut waste. Perhaps you will be able to think of others.

• ***Sawdust mixing bowl (pictured on cover).***

Procedure

1. Select two pieces of preformed clear plastic. This plastic can be uneven in shape with scratches on one side. The thickness should be ⅛ inch to $\frac{3}{16}$ inch.
2. Heat this preformed plastic and it will go back to its original shape. Place it on the worktable to cool, turning it over and moving it from place to place on the table to keep the plastic level. WARNING: Do not place the hot plastic on a finished worktable or the finish will transfer to the hot plastic.
3. Measure and mark two 12 x 12 inch pieces. Then cut these squares out on the band saw or the circle saw.
4. Gather the plastic dust from the saws or sander. Specific colors may be had by selecting scrap pieces and sanding them into dust on the disc sander or the saw, using the carbon grit saw blade.
5. Place this plastic dust on one of the pieces of 12 x 12 inch clear plastic. Place the dust so that it is ¼ inch thick in the center and gradually reduced in thickness to $\frac{1}{16}$ inch at the outer edge. If the plastic is scratched, place the dust on the scratched surface.
6. Place the plastic with the dust in a preheated oven at 350 degrees F. and heat until flexible—20 to 25 minutes. After it has heated for 10 to 12 minutes, place the second piece in the oven.
7. As the plastic is heating, prepare the forming press and mold for use. Build up from 90 to 100 pounds of air pressure. Adjust the forming press to place the mold on the plastic without delay.
8. Place the plastic with the dust in the forming press. Put the second heated piece on top of the plastic dust. Then place the mold on the plastic and tighten airtight. Always use gloves to handle hot plastic.
9. Open up the air valve and watch the bowl move into shape. Turn the air off and watch to see that the bowl stays in shape. If the bowl starts to reduce in size,

turn the air on and off enough to keep the correct size. Continue for 12 to 15 minutes until the plastic cools.

10. Remove the mold and the plastic from the forming press.

11. Remove the plastic from the mold, pressing a screwdriver between the mold and the plastic if necessary.

12. Using the band saw, cut the outer edge round.

13. Sand the edge smooth, using a disc sander.

14. Scrape and hand sand the edge.

15. Buff the edge to a high polish.

• ***Mixing bowl made of a discarded sign (pictured on cover).***

Always use two pieces of this scrap plastic and be sure to place the painted surfaces together. Never place a painted surface on the oven rack, as the paint will get on the rack and mold and scar the plastic.

Procedure

1. Saw out two pieces of plastic, 12 x 12 inches, using ⅛ inch or $^{3}/_{16}$ inch stock.
2. Place these two pieces of plastic together with the polished surfaces on the outside.
3. Heat the plastic in a preheated oven at 350 degrees F. Allow the plastic to stay in the oven for 12 to 15 minutes until it is flexible.
4. Now complete the bowl by following the same procedures used in Steps 7-15 for the sawdust mixing bowl.

• ***Making a plate from a discarded sign (pictured on cover).***

Procedure

1. Select the plastic from ⅛ inch stock.
2. Mark off and saw out two pieces of 9 x 9 inch plastic. Consideration should be given to the design of the painted surface. However, try not to waste the material as it is marked off.
3. Place the two pieces with painted sides together and the polished surfaces on the outside. This will give one design for the top and another for the bottom.
4. Place both pieces of plastic in a preheated oven for 12 to 15 minutes at 350 degrees F. and heat until flexible.
5. While the plastic is heating, prepare the forming press and the die for use. Build up from 90 to 100 pounds of air pressure on the forming press and adjust it so that the plastic and the die can be placed without delay.
6. Using gloves, place the hot plastic in the forming press. Then place the die on top of the plastic and secure them airtight.
7. Turn on the air. If there is no drop in air pressure on the gauge, the plastic and the mold are placed correctly. If there is a drop in air pressure, cut the air off, reheat the plastic, and start over.
8. Allow the plastic to cool in the die and the forming press for 15 minutes.

9. Remove the die and the plastic from the forming press. Then remove the plastic from the die.

10. Using a band saw, saw the plate round. The die has made a rim around the outer edge of the plate that is used for a guideline in sawing.

11. Sand the edge smooth using a disc sander.

12. Scrape and hand sand the edge.

13. Buff the plate to a high polish.

• ***Notepaper holder (pictured on cover).***

This is a good project to make from discarded signs with designs painted on one side.

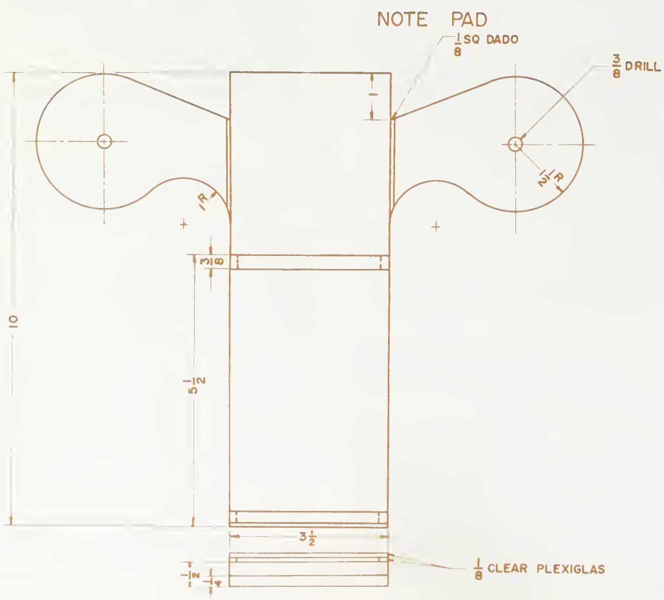
Bill of Materials

2 pieces 10 x 12 inch plastic, ⅛ to ¼ inch thick
2 pieces ⅛ x ⅜ x 3½ inch clear plastic
4 pieces ⅛ x ¼ x ¾ inch clear plastic
1 wood dowel, ⅜ x 3½ inch

Procedure

1. Saw out two pieces of 10 x

Drawing for notepaper holder.



12 inch plastic with painted design on one surface.

2. Place the two pieces together with the painted surfaces on the inside.

3. Heat these pieces in the oven at 300 degrees F. for 10 to 15 minutes to fuse the plastic.

4. Remove the plastic from the oven and allow to cool.

5. Lay out the pattern on the plastic.

6. Cut out the pattern, using the band saw.

7. Saw the dado. This groove enables the workman to bend a right angle.

8. Mark off and drill the ⅜ inch holes for the wood dowel.

9. Sand and buff the edges to a high polish.

10. Place the plastic on the strip heater with the dado groove directly over the heating unit. Heat on both sides until the plastic is flexible.

11. Bend to a right angle.

12. Make the small clear pieces and cement onto the pad holder as shown in the drawing.

13. Using the wood dowel, assemble a roll of adding machine paper.

INJECTION MOLDING

The injection molding machine may be operated by one person. In the classroom, however, if several items are to be made, it is a good idea to have one person operate the controls of the machine and another assemble the mold in the machine, remove the mold, and remove the formed plastic item from the mold. This way the process works more smoothly, producing more items during a short period of time.

The quality of the plastic item is determined by the quality of the plastic used, the accuracy in setting the controls, and the ability to judge the correct removal time when taking the plastic from the mold. The time needed to form each item is determined by the thickness of the item and the method used for cooling the mold. When the operator opens the mold and finds that the molded item is flexible, more cooling time is needed before removing the mold from the machine.

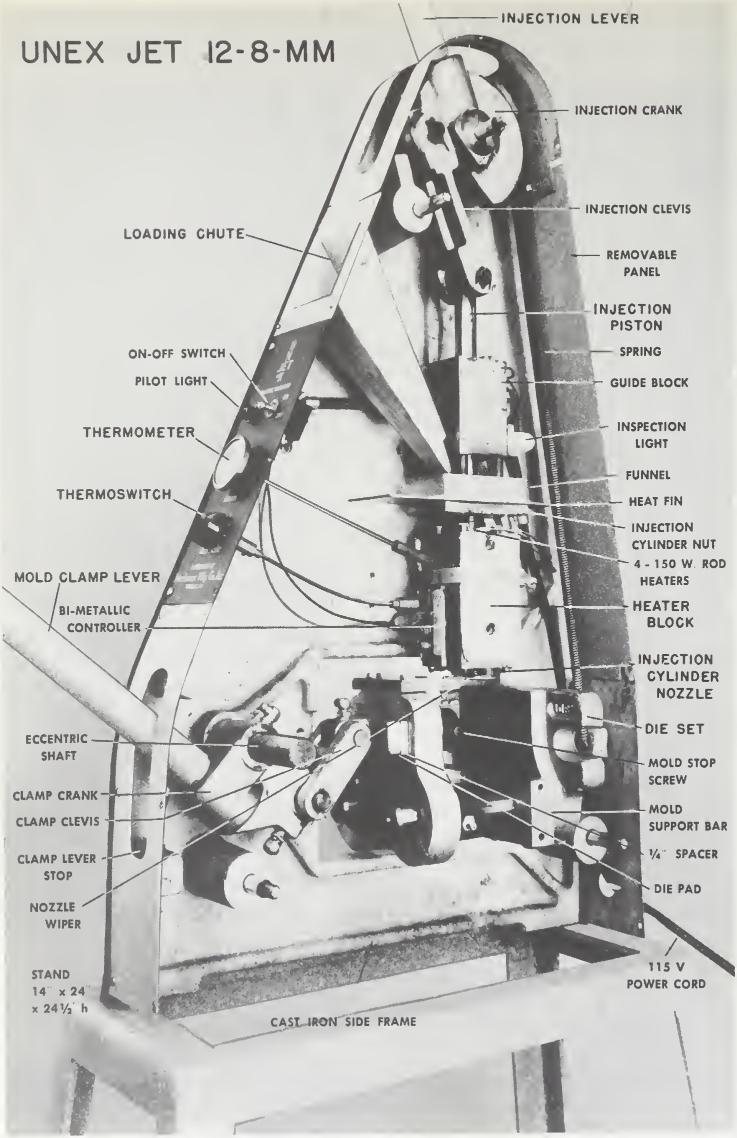
Operating the injection molding machine is much like learning to drive a car. First, you must learn how to operate the machine, and then you will need practice in order to become efficient.

Molds are an important part of the injection molding process, since they determine what is made by the machine. Custom-made molds can be expensive. However, the two methods that follow can be used to make relatively inexpensive molds:

Procedure for Making a Mold of Liquid Metal

1. Make a wooden box that measures 3 inches square inside. Assemble it so that it can be taken apart with screws.

2. After making the box, fill the bottom half with modeling clay



HINCHMAN MFG. CO.

Injection molding machine, showing the inside section and name of each part.

which can be sculptured to the first half of the selected design.

3. Heat the clay and box in an oven at 150 degrees F. for 3 hours. This is done to reduce the moisture content of the clay and the box.

4. Prepare the liquid metal. Be sure the materials used are well mixed. The proportions used in this model call for one part of hardener for every 3.5 parts of liquid metal. Place this mixture in a double boiler and heat it at 212 degrees F. Mix for at least 5 minutes.

5. Apply mold release to the inside of the box.

6. Pour the mixture into the box. Place the unit in a preheated oven at 250 degrees F. Heat for 5 hours.

7. Remove the unit from the oven. Take the screws out of the box and disassemble the unit.

8. Sand the molded metal smooth on the disc sander.

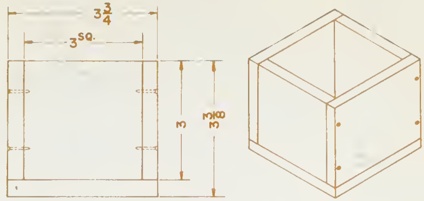
9. Make the second half of the mold in the same manner.

10. Drill guide pinholes and use studs so that the two halves of the mold will fit together.

11. This mold works well at a temperature of 350 degrees F. and at a pressure of 20 pounds per square inch in the injection molder.

Procedure for Making a Mold of Machined Steel (Drawing page 272)

1. Make the L-shaped part of the mold by welding a top piece (1¼ x 2 x 3 inches) onto the top of a bottom piece (1 x 3 x 3 inches).



Drawings for wooden box mold for pouring liquid metal.

2. Use a surface grinder to machine this part smooth.

3. Cut another piece of steel, 1¼ x 2 x 3 inches. Machine this part smooth.

4. This forms the main part of the mold, leaving a center section that the engraved part will fit into securely when clamped in the injection molder.

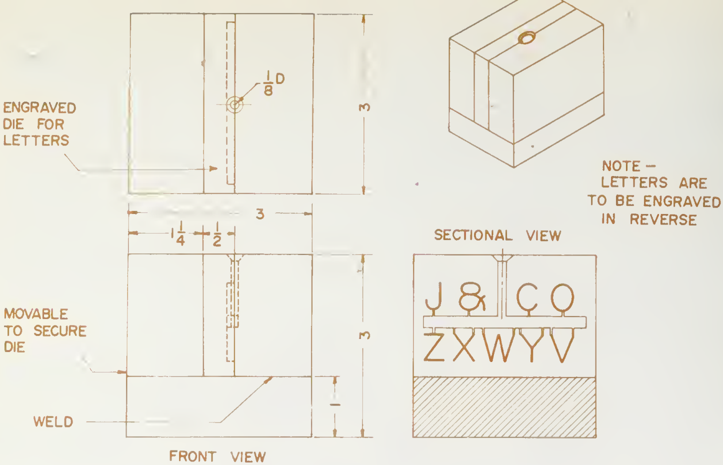
5. The center part is ½ x 2 x 3 inches. When put together, the three machine pieces will make a mold 3 inches square, the required size.

6. The only part left is designing and machining the project to be made by the injection molder. The design is cut into the center section of the mold. The milling machine, drill press, and pantograph engraver can be used to make the desired design.

Procedure for Using the Unex Jet Molder

1. Connect the air pressure hose to the machine. Let the air pressure of the molding machine build to 25 p.s.i.

2. Set the thermostat at 350 degrees F. A red warning light



Drawings for mold made of steel.

will come on when this temperature is reached. It takes only a few minutes (approximately 5 to 10) for the unit to heat.

3. Open the mold that is to be used. Spray the inside of the mold with plastic mold release.

4. Assemble the mold. The guide pins help it fit together correctly.

5. Insert the mold into the injection cylinder. Care must be taken here to make sure that the hole in the mold is directly under the injection nozzle. NOTE: The machine is set to fit only one mold size; there is an adjustment screw for alignment of the hole and nozzle.

6. Clamp the selected mold in the machine by pulling the clamp lever down. The lever locks in place.

7. Pour polyethylene plastic pellets into the loading chute. Keep the pellets punched down. The chute must be kept filled when in use.

8. Push the air pressure lever down. This pushes the melted plastic into the mold. Wait 5 seconds and release.

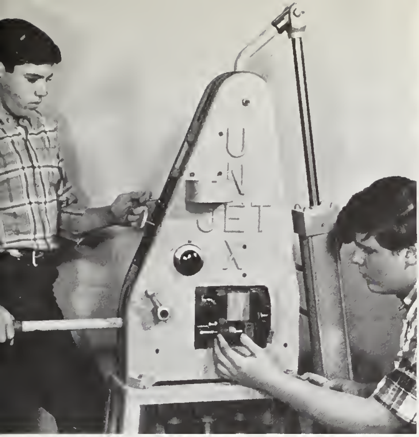
9. Release the mold by pushing the mold clamp lever up.

10. Take the mold out of the machine.

11. Take the mold apart. Continued use will cause the mold to heat. An air hose is used to cool the mold instantly.

12. Take the project out of the mold.

13. The mold is ready to use again. By using the air hose for cooling, the same mold can be used as fast as the machine can be operated, which is only a few seconds.



Operating an injection molding machine.

Removing letters which have been formed in the injection molding machine.

Questions on Problem Solving in the General Shop

1. List equipment needed to add plastic to the general shop curriculum.

2. What are some suggested projects to make of wood and plastic?

3. Name three projects concerned with combining plastic with mechanical drawing.

4. Name three plastic-and-metal projects.

5. Name three plastic-and-electricity projects.

6. Which turning tool is used to make the ring on the lathe in the ferris-wheel Lazy Susan?

7. What could cause the three-layer lazy Susan to turn unevenly?

8. How long should a 2½ inch cube of plastic be heated to make a curved-hole paperweight?

9. How thin should the hot cube of plastic be pressed in the vise when making a curved-hole paperweight?

10. What is used to protect the plastic from the vise jaws when it is to be pressed thinner?

11. What plastic thickness is used to form the flower container for the rolling pin planter?

12. What is one of the properties of acrylic plastic that makes it valuable as a material to combine with the working of electricity?

23 MINIMUM EQUIPMENT FOR A CAMP OR VACATION SHOP

Working with plastic, using minimum equipment, is an industrial arts subject often taught in other fields of education and recreation as an incentive to develop interest, and to discover and develop abilities. The work in camps, "Y's," vacation retreats, craft classes, or Boys' Clubs adds an oportunity to teach more skills and often develops more interest toward the group's activities.

• *Power and heating tools needed.*

1. A buffer.
2. A disc sander.
3. A hot plate.

The electric motors for the buffer and the disc sander may be secured from discarded household appliances. The buffer is mounted onto the motor shaft with a work arbor, and the disc sander is mounted onto the motor shaft

Camp projects made of plastic using minimum equipment.

with a faceplate. It is important that the work arbor and faceplate have a bore the same size as the shaft on the motor. For an example, if the shaft of the motor is ½ inch, the hole in the work arbor and faceplate is to be the same. The disc sander is made by cutting out a disc from plywood ¾ x 8 inches, and gluing sandpaper to the face of the disc.

An oven can be made by using a metal bread box over the hot plate. This is done by cutting out one side of the box and mounting woven wire over it. The cut-out side is placed over the hot plate and the top lid is used for a door. Plastic must be checked frequently and taken out to be formed as soon as it is flexible, because the oven does not have a heat control.

To make a more permanent type of a hot plate oven, two metal bread boxes are used. One box is approximately 2 inches smaller than the other one. The smaller box is placed inside the larger one and weather insulation is packed between the two boxes.

- ***Hand tools needed.***

1. Hand saw—fine tooth.
2. Coping saw
3. Hand drill.
4. Cabinet file.
5. Spring clamps.
6. Pliers
7. Gloves
8. Glue pan.
9. Scratch awl.
10. Screw clamp.
11. Rule.
12. Dividers.
13. ⅛ x ¼ inch twist drills.

- ***Molds and jigs needed.***

1. Towel ring mold.
2. Small mold for round bowl.
3. Large mold for round bowl.
4. Mold for bowl with corners.
5. Candle holder mold.
6. Jig for sawing, filing, and sanding.

These molds and jigs may be made in an industrial arts class or at home. The sizes and designs depend on individual wishes.

- ***Supplies needed.***

1. Selected plastics.
2. Ethylene dichloride.
3. Buffing compound.
4. Wax.
5. Dye powder.
6. Acetone.
7. Sandpaper.

- ***Suggested projects.***

1. Candle holders.
2. Necklace.
3. Bracelet.
4. Cross.
5. Tray.
6. Key chain fob.
7. Picture frame.
8. Towel rings.
9. Towel rack.
10. Napkin holder.
11. Letter opener.
12. Bill file.
13. Ear screws.
14. Cattail centerpiece.
15. Box.
16. Airplane model stand.

17. Bowls.
18. Windshield scraper.
19. Apron hoop.
20. Letter holder.
21. Name plate.
22. Paperweight.

• *Major operations to be learned.*

1. Sawing plastic with a hand saw or a coping saw, using a jig. The plastic is placed in so as to saw the kerf within ⅛ inch of the jig, to prevent breaking. Apply little pressure on the saw while sawing, to avoid large saw chips and to prevent breaking thin plastic.

2. To file plastic in a jig, clamp in such a way that the edge to be filed is ⅛ inch or thinner. The cabinet file is used to remove saw marks and chips. When filing straight edges, hold the file level and lengthwise to the plastic. Keep even pressure on the file at all times. When curved edges are to be filed, a rolling stroke is applied, using the rounded side of the cabinet file. Care must be taken at all times when filing plastic ⅛ inch or under to prevent breaking.

3. Buffing plastic—See the chapter on buffing.

4. Sanding plastic on disc sander—see the chapter on sanding.

5. Heating and forming plastic that is too large to go in the bread box oven is done directly over the hot plate, holding the plastic in gloved hands and moving it over the heat a portion at a time until all parts are flexible. *Asbestos gloves* are worn. Never allow some portions to get too hot, or blisters will appear. Turning the plastic over and heating from both sides helps to heat the plastic evenly. When flexible, it is placed into the mold and formed.

6. To drill plastic with a hand drill, make a dent where the hole is to be drilled, using a scratch awl. Clamp the plastic on a scrap piece of wood with the screw clamp. To drill the hole, keep the hand drill at a right angle to the plastic at all times. Turn the drill at a slow speed. This is to prevent chipping as the drill goes through.

7. Gluing plastic—see the gluing chapter.

Questions on Shop Equipment

1. What power tools are needed for the minimum equipment shop?
2. What is used to mount the buffer on the motor shaft?
3. What is used to mount the sander on the motor shaft?
4. How is a disc sander made?
5. How may an oven be made for minimum shop equipment?
6. What hand tools are needed for the shop with minimum equipment?
7. Name five molds and jigs that are needed for the shop with minimum equipment.
8. List the supplies needed for the shop with minimum equipment.
9. What suggested projects may be made with the equipment and supplies listed?
10. What major operations may be learned with the equipment listed?

24 THE PLASTICS INDUSTRY AND YOU

Planning a Career

When will you start thinking about a career? At the last minute when you feel compelled to take an unskilled job with low pay? After you've taken the first job that comes along and discover that it's not really what you wanted? If you wait, it may be too late to get what you really want. What better time is there to think about the future than now? Job training is vital to your future and choosing the right skills to learn is even more important.

As you read in the early pages of this text, the plastics industry is growing by leaps and bounds. Since World War II it has been growing at a rate double to that of all manufacturing. Plastics will eventually affect every industry and every type of manufacturing.

What do these facts say to you? As a potential job seeker, you will want to train for a job with a future. The plastics industry has a future for you if you make the effort.

While the usage of plastics in industry is increasing at remarkable rates, the availability of trained engineers, technicians, and skilled workers has been decreasing. You can take advantage of this by acquiring the skills needed to find a place in the plastics industry.

What job opportunities are there in plastics? In the first place, the need for skilled (trained) employees is great. Some of the essential skilled positions are listed here. Keep in mind that the titles may vary in different companies even though the responsibilities are the same.

- Mold and die makers.
- Supervisors and foremen in the tool room and in processing and finishing.
- Mold and product designers and draftsmen.
- Mold set-up technicians.
- Production engineers (cycle and material technicians).
- Inspectors and quality control technicians.
- Processing, accessory, and finishing machinery specialists.
- Color and material mixing specialists.

Training for skilled jobs can be secured in different ways. Many high school programs will provide courses in plastics to begin your training. After high school, there are other schools, including junior colleges, with programs that teach skills. Even the industries have training programs that take those

interested through courses and apprenticeships, leading to skilled jobs with the company. Remember, however, that the more background you have in the field of plastics, the more likely you are to be chosen for a particular training program or job. This is why taking the right steps early can be so important later on.

The importance of acquiring skills cannot be overemphasized. In a recent national survey conducted by the Joint SPE-SPI Education Committee, over 4,000 plastics firms were asked which of the following they would prefer to hire:

- Non-high school graduates willing to learn.
- High school graduates with no special plastics training.
- High school graduates with plastics training.

Of all replies, 78% indicated a preference for high school graduates with plastics training as compared with 16% for high school graduates with no plastics training and 6% for non-high school graduates willing to learn. Moreover, 84% of these companies were willing to pay extra to the high school graduate with plastics training. Do you see from these figures how important training is?

In addition to skilled workers, there is also a critical need for graduate engineers in plastics, particularly in large companies. Through the engineers comes the continuous development of new and improved materials, increasing the use of plastics for more products and opening bigger markets.

Even the graduate engineer, however, may need more training when he leaves college for an industrial job. Mechanical and industrial engineers, in particular, are not usually trained in the specifics of working with plastics. On the other hand, chemical engineers are more likely to make immediate contributions in some areas without additional training. The important point here is that if you plan to work in the plastics industry after college, the more courses you take which are directly related to plastics, the better off you are likely to be when seeking a job.

• *Choosing the Right Job*

There are many different types of plastic and plastic products. For example, polyester has become a household word because of its use in such products as clothing and tires. Working with this substance, chemical engineers have changed the components of this basic polyester in such a way as to enable the industry to make not only tires and clothing but also fiber glass boats.

Like the great number of products, the range of specific job titles in the industry is also quite wide. Industry has different titles for jobs which are similar but not identical. For example, the injection molding industry has a job called "tool and die maker," but a similar job in many fabricating industries is listed as "mold maker." In the previous chapters of this

book, discussions on the making and using of molds and dies shows to some extent the difference in these two pieces of equipment as they relate to the job.

A closer look at some of the positions available in the plastics industry may help you choose the right job for your future.

MANAGEMENT AND ENGINEERING POSITIONS

Some jobs in the plastics industry require a basic knowledge of management or engineering. A college education will probably be required for most of these jobs. The following are examples of management and engineering positions:

Personnel Management

Although personnel management is a vital part of the industry, the qualifications of these professional people are generally the same as for managers of other industries. Personnel managers must understand the general workings of the plastics industry well enough to choose the right people for the jobs.

Production Management

The person in charge of production management has two vital responsibilities. First of all, he is responsible to the company for the production of a product, competitive in quality and price, yet allowing a margin for profit. Secondly, he is equally responsible for the welfare of the people who are employed in the production of this item.

Chemical Engineer

The growth of the plastics industry is indebted much to the chemical engineers. Through the years they have developed hundreds of different kinds of plastic. This job will continue to be important, not only to develop new kinds but also to improve or change previously developed plastics.

Mechanical Engineer

One of the mechanical engineer's major contributions to the plastics industry is the designing of machines and related equipment to produce plastic items. He is also responsible for establishing directions for the proper operation and maintenance of the machines. Among these engineers are draftsmen and technicians whose knowledge and skills vary in different industries; therefore, they are usually given specific training by the industry.

Electrical Engineer

Many plastic items are made with machines which are electrically heated and powered. The electrical engineer is charged with much of the responsibility in designing machines for specific uses. He is also responsible for proper operation and maintenance.

SKILLED POSITIONS

Other jobs in the industry require specific knowledge and

Often people who choose careers in the plastics industry first develop an interest in plastics while in school. Many basic industrial techniques are taught in the plastics shop. These boys, as they operate a riveting machine, are part of an assembly line which is turning out football helmets.

skills. The following job descriptions are examples of these:

Assembly Line Workers

The leader of an assembly line in some plants may be called a foreman, production manager, inspector, or quality control workman. The foreman should be a person who can correctly instruct each workman on how to do his job to achieve speed, efficiency, and quality. He is also responsible for keeping the assembly line flowing smoothly, for if one workman is behind in his production, it will slow down the rest of the line.

Usually the assembly line is divided into departments directed by middlemen with direct supervision and instruction under a foreman. For example, in assembling football helmets, jobs may be divided into different assignments such as the following: (1) riveting the correct parts; (2) cementing the padding to the inside, requiring as many as three workmen, each putting different parts or padding on; (3) assembling the nose guard onto the helmets; (4) supplying work stations with adequate parts; and (5) inspecting to insure quality work. Often managers, foremen, and inspectors start their careers on the assembly line.

Color Workman

Knowledge on the proper mixing of dies, liquids, and pastes is important for this position. More and more different colors of plastic are appearing on the market. This is the result of work performed in the lab to create colors, as well as the efforts of workmen who must know how to add the proper amount of coloring to large quantities of plastic material.

Cycle Workman

This job operation is usually found in plastics industries that use injection molding, calendering, compression molding, transfer molding, and extrusion molding. There are various stages in all of these processes, and the cycle workman is concerned with the timing of each stage plus correct heating and cooling. The machines or equipment, if set correctly, will

produce each stage as needed. Therefore the cycle workman is concerned with a series of gages and meters, since the usual automatic machines function with the help of a machine operator.

Designer

Designers, draftsmen, and artists work closely together, each needing information on the qualities and properties of the plastics used by their industry. For example, a company may receive a request from a customer describing his need for a particular item. Often the decision on whether or not the company can make the item rests with these workmen. If they decide the item can be made, they submit plans, including drawings, art, designs, and often a model made from other material. Often these same workmen are responsible for instructions to the die makers as well as production makers.

Forming Acrylic Plastics

One of the major uses of acrylic plastics is for signs. A mold, often made of wood or fiber glass, is a necessary tool in forming plastic. To many workmen it is exciting to design and to make a mold which will enable them to form a piece of acrylic plastic to meet their own needs as well as the needs of their customers. Learning to use a forming press, an oven, and a mold is essential in forming plastic. Also, the worker must learn to control temperature, judge the oven-time needed for heating, place the plastic on the mold, and operate the press.

Acrylic plastics are used to make signs like the one shown here. With a career in forming acrylic plastics, you may help produce such signs.

Machine Operator

This workman's major duty is to watch the time gage. In addition, he may watch the flow of plastic material into the machine and the finished product as it comes out. Some procedures require the machine operator to remove a plastic item from the die and then place the die back into the machine, whereas others need only know when the machine is operating correctly and how to adjust it when it is not. Many of these machines and operations are discussed and illustrated earlier in this text.

Quality Control Workman

The quality control workman, sometimes called inspector, is

often a double check on the machine operator. His duty is to inspect the items from one or more machines periodically, to determine if they are of the necessary quality. To do this, he must know what the specifications are and be able to check them, using a micrometer, patterns, templates, scales, color charts, or other devices. Usually it is his responsibility to stop production if problems occur.

Silk Screen Workman

This workman, in effect, transfers the ideas of the artist and the draftsman onto a screen, which is then transferred to the plastic. This is a major operation in industries that make signs. Accuracy is most important. For example, if there is a flaw or a mistake in making a silk screen, it will be transferred as often as the screen is used. The use of the silk screen requires a knowledge of correct procedures and accurate placing on the plastic.

Tool and Die Maker

Sometimes called a "mold maker," this worker has the responsibility of making the die or the mold that will enable the workman to produce an item of the required shape and size. He must not only understand what the designer wants but he must also be skillful in using the particular industry's machines and tools. Often his work is on a very close tolerance, requiring skill, patience, knowledge of the plastic's properties, and an understanding of the machine on which the die is used. Sometimes he must also be familiar with the properties of the material used to make the die, such as different qualities of steel and wood. In many industries, skill in making a quality die is preferable to speed in making a lower quality die.

Small Tools and Equipment Worker

This workman uses saws, drill presses, and other shop tools as a major part of the production of formed acrylic plastics. The job may consist of the use of a portable saw one day, a band saw the next day, and a drill press on the third. These workmen must be skilled in the use of these small tools and knowledgeable about the properties of acrylic plastics.

Utility Workman

Here is an interesting job for the workman who likes to see the wheels keep rolling. With some general knowledge on much of the equipment that is used in the industry, he repairs or adjusts equipment that is not functioning properly. The student who takes an interest in knowing the details about the equipment he is using and learning how to repair and adjust it would probably enjoy a career as a utility worker in a plastics industry.

Now that you have read about jobs in the plastics industry, the rest is up to you. Investigate the job opportunities where you would like to live and work. Discover the

kind of job you want in the plastics industry and learn more about it. If you are not interested in an industrial job, you may want to investigate the possibility of teaching. For real firsthand information, enroll in plastics courses to see if you like working with plastic and to become more familiar with the work. Then look for the place that can provide you with the necessary training for the job you want. It may seem early to think about a career now, but in the years ahead you will surely be glad you did.

Buying plastic products

Even if you never work for a plastics company, the industry will still be very important to you. Every day you use items made from plastic. Often you purchase plastic goods. The more familiar you are with plastics, the easier your role as a consumer becomes.

When buying plastic items, use the same good buying techniques that you would use when purchasing other goods.

First of all, learn as much about the product as you can, particularly if it is a major purchase. Some plastics are commonly known. Generally the consumer is informed about the items he buys which are made from these plastics. For example, the person who buys a pair of nylon hose, a fiber glass boat, or polyester clothing or tires is usually informed about the quality and fair price of these items. Many plastic items, however, are made of a plastic which is unknown to the average buyer. The mother purchasing a plastic toy car for a child's gift is not apt to know the quality of the plastic used and so may not be able to determine if the toy is of good quality. If your investment will be a large one, you might be wise to find literature which will help you judge the product. Choosing carpeting, for example, will be much easier and you will probably be happier with your decision later on if you learn what to look for in advance. Magazines, such as *Consumer Reports*, can be a big help in providing the information you need on different products. In addition, tags that accompany the merchandise often have valuable information concerning the material in a product. For small purchases, like the child's toy car, you won't usually need to do this. Instead, look for these signs of poor plastic merchandise: lightweight material, apparent poor durability, poor construction; the presence of spurs, cracks, and rough places; parts which are not uniform; loose parts; or parts that do not work smoothly. Check large purchases for these flaws also.

A second point to keep in mind when buying plastic goods concerns the price. Plastic items come in all price ranges. The builder of a department store who uses plastic room dividers in the decor chooses plastic of good quality because the dividers must be durable. The same builder, who uses plastic sheets to cover his material

Plastic items come in different qualities and price ranges. How many items do you see in this office that might be made all or partially from plastic? What quality of plastic would you choose for the different uses?

to protect it from the weather, chooses inexpensive plastic that will serve the purpose even though it costs little. The plastics industry has developed cheap plastic materials to use in making items like throwaway bottles and packaging. At the same time, industry has also developed expensive plastic which takes the place of steel or other metals for tubing and gears. Plastic has the advantage of rust resistance in these uses. Whatever the item, remember that an unusually inexpensive price usually reflects low-quality materials and workmanship. On the other hand, a very high price does not always mean the product is the best available for your money. You will want to think about use when you decide on the quality and price of an article.

Another key to getting the most for your money is this: Compare prices to find the best buy. Many products which serve the same function are made from plastic of different qualities. Food storage containers, for example, come in a wide range of qualities and prices. Some, however, will crack after little use. Others will last for years. Once you decide what quality you want, by watching the ads and observing merchandise in more than one store, you may be able to save money on your purchase.

Finally, buy from a reputable dealer or manufacturer. This is one of the best ways to be sure of quality. Unfortunately, many buyers have learned about poor-quality plastics through trial and error. An umbrella handle breaks, the raincoat and golf bag split the first time used, the television case cracks—these are all problems that consumers have encountered. Reputable dealers and manufacturers do their best to know the properties of the plastics in their products and use the best quality for the price and purpose. By buying brand names from well-known dealers, you can be more confident about the product and the response you will get if a problem arises.

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